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Fig. 1.—Bringing the Ends of the Cables Ashore.

Fig. 2.—On Reaching the Farther Bank the Cable Ends Are Taken Off the Drums.

LAYING OUT A CABLE SYSTEM UNDER THE RIVER TRAVE—[See Page 40]

# A Promising Industry

## Statistics of American Fuel Briquet Manufacture

By Guy E. Mitchell

Good progress is being made in the development of fuel briquetting in the United States, according to information which is being compiled by Edward W. Parker, the statistician of the United States Geological Survey. In 1908 the production of fuel briquets in the United States was 90,358 short tons, valued at $323,057. In 1909 it was 139,661 short tons, valued at $452,697, which was an increase of nearly 55 per cent in quantity and about 40 per cent in value. In 1911 the production amounted to 212,443 tons, valued at $769,721, a further increase in two years of 72,782 short tons, or 52 per cent in quantity, and of $317,024 or 70 per cent in value.

Although this is a good rate of increase, the present production is insignificant when compared with that of some of the European countries, particularly Germany. The subject is, however, one to which Mr. Parker believes attention should be given, as upon it depends, in a large measure, the utilization of some grades of fuel, which are now wasted or sold at less than the actual cost of production—the products of both bituminous and anthracite mining. The reprehensible, but growing practice of shooting bituminous coal "off the solid," notably prevalent in the non-coking coal fields of the Mississippi Valley, produces an inordinate proportion of slack, an undesirable product which is difficult or impossible to sell, and, in fact, by the best mining practice the quantity of slack produced is frequently too large to be profitably disposed of.

This bituminous slack is readily briquettable. The principal factor operating against the more rapid development of fuel briquetting in these non-coking coal fields of the Middle West is the low price of the raw fuel with which the briquets have to compete, and so long, probably, as new areas can be, without restriction, opened up, and the supply of cheap coal continued, so will the present profligacy be maintained and the slack continue to be unused except to a limited degree.

The average price for coal in the northern Middle States in 1911 ranged from about $1.10 in Illinois to about $1.75 in Iowa and Washington. The cost of manufacturing briquets, exclusive of the cost of raw matial, is about $1.00 a ton, and although briquets possess undoubted advantage for domestic use over raw coal, particularly when the latter is unsized, householders must be educated to the fact that the higher cost of the briquets is more than offset by their desirability and greater economy in actual use. The briquet, as a matter of fact, makes a very fine fuel, especially for domestic uses.

In Germany, where the price of coal is relatively high, and the cost of labor relatively low, the briquetting industry has made extraordinary progress. In 1910 the production of briquets in Germany was 16,-668,605 short tons, and in 1911 it was 18,554,020 short tons. Compared with these figures the production of 212,443 short tons of briquets in the United States falls into significance.

In the anthracite field of the East there is a probability of more substantial development of briquetting in the near future by reason of the advance of 25 cents a ton on the domestic sizes of anthracite coal, in the spring of the present year, which followed the advance of 10 per cent in wages agreed upon as the result of the strike in the anthracite region, on April 1. There is little possibility of any future reduction in the prices of this fuel. In fact, Mr. Parker states that further advances are more to be expected, since it is rumored that one of the large owners in the anthracite coal field will upon the expiration of present contracts exact an advance of 25 cents in the royalty to be paid. Other owners of the land will naturally follow suit, and the public will be called upon to foot the bills. It seems reasonable, therefore, to suggest that the utilization of the small sizes, by manufacturing them into briquets for domestic use, on which a profit could be secured, might be more rational than selling them, as is now done, below the cost of production, because as a steam-raising fuel they must be sold in competition with bituminous coal. The quantity of this grade of raw material for briquetting is enormous. In 1911 the shipments of anthracite below pea coal in size amounted to over 20,000,000 long tons, of which 85 per cent was mined in that year. The culm banks which still remain in the anthracite region, unsightly monuments to the wasteful mining methods of other days, contain millions of tons of usable small coal. From 3,000,000 to 4,000,000 tons of this fuel are being recovered annually by washeries, the product yielding only a small return, which amounts to a reduction, simply, in the average cost of production. The 20,000,000 tons alone of small sizes mined in July was worth not to exceed $30,000,000. If manufactured into briquets of egg and stove size this tonnage, according to Mr. Parker's estimates, would have been worth $70,000,000. The cost of briquetting, most of which would have been expended in the employment of labor, would have been, he says, $25,000,000. In other words, he estimates that the outlay of $20,000,000 would have brought a return of 60 per cent in profit, and would have furnished an ideal domestic supply to that extent.

One hindrance to the development of the briquetting industry to which the Geographical Survey and many engineers have already called attention, has been the absence of a regular supply of binder at reasonably steady prices. But the concomitant industry from which coal tar pitch, as this binder, may be secured, namely, the manufacture of coke in byproduct ovens, has shown notable progress in the last two or three years, and as the byproduct oven seems destined to largely, if not entirely, supplant the beehive coke oven, the supply of coal tar pitch at reasonably low cost should be assured.

There seems no question of the steady increase in production of byproduct coke, and therefore of one of the principal byproducts, coal tar. In 1908 the byproduct coke output was 4,201,226 tons; in 1909 it was 6,254,644 tons; in 1910 it was 7,138,134 tons, and in 1911 it was 7,847,845 tons. The increase has been steady, even in the year 1911, when the total production of coke was 15 per cent less than in 1910. The increase in the coal tar byproduct has been correspondingly great.

The following table shows the gains in both products:

PRODUCTION OF BYPRODUCT COKE AND THE COAL TAR BYPRODUCT 1908-1911.

| Year. | Coke, Short Tons | Coal Tar, Gallons. |
|---|---|---|
| 1908 | 4,201,226 | 42,720,609 |
| 1909 | 6,254,644 | 60,126,006 |
| 1910 | 7,138,734 | 66,303,214 |
| 1911 | 7,847,845 | 75,574,747 |

The figures on the recovery of the coal tar from byproduct coke produced in 1911, are not yet available, but 75,574,747 gallons, are estimated on the basis of 9.63 gallons of coal tar from every ton of byproduct coke.

Our total production of coke ranges from 35,000,000 to 40,000,000 tons a year, and will probably never run less than the 35,055,362 tons output of 1911. If all of this coke had been made in byproduct ovens it would have yielded the enormous amount of 342,000,000 gallons of coal tar pitch.

In addition to the slack from bituminous, sub-bituminous, and semi-anthracite non-coking coal and the dust and small sizes of anthracite, three other sources of raw material for briquetted fuel are available, namely, lignite, peat and coke breeze. European practice has shown that the briquetting of lignite and peat can be better and more economically accomplished without the use of a binder.

The utilization of coke breeze presents a problem distinctly its own—the destructive abrasive action of the crushing apparatus, the bearings of the machinery, and the briquetting molds. It has been truly said that coke dust "cuts like a diamond," and the repair and replacement of the parts of the machinery affected by it make expensive items in the attempts that have been made to use coke breeze in the manufacture of briquets.

The quantity of breeze produced in the manufacture of coke amounts to between 2,000,000 and 3,000,000 tons annually.

The supplies of lignite available in North Dakota and Texas are to all intents and purposes limitless. That of North Dakota alone is estimated by the Geological Survey as 500 billion tons. The peat deposits constitute great areas in the drainage basins of the Great Lakes and the Atlantic seaboard. They are generally somewhat remote from the coal fields and the product when properly prepared makes an excellent substitute for the more expensive coal.

The Los Angeles and Electric Corporation, of Los Angeles, California, operates a briquetting plant for utilizing the carbon obtained as a byproduct in the manufacture of illuminating gas from crude petroleum. The briquets, or "boulets," make excellent domestic fuel.

Mr. Parker has maintained the position for some years that careful investors have been kept back from ventures in briquetting enterprises by attempts which have been and continue to be made to exploit secret binders and processes from which extraordinary merits are claimed, but which have not proved successful in commercial operations. The pathway of briquetting development, he says, is strewn with wrecks due to this cause. There is absolutely no reason for secrecy in connection with the constituents of patented binders. The field to be developed is so large that there is room for everyone to engage in the industry along conservative lines, and in well beaten paths, the result of the experience of European countries.

Twenty plants in the United States manufactured compressed fuel in 1911, an increase of four over 1909. Four of the twenty plants in 1911 were operated only in an experimental way, or for demonstrating purposes, and of those that were operated as commercial plants, eight used anthracite as a raw material, two used bituminous coal, two used semi-anthracite, one used refuse from oil gas works, one used peat, and two used mixed material. The various manufacturers place their products on the market under special names, such as "boulets," "eggettes," "carbonets," "coalettes," "patent fuel," etc., but all may be included under the general term, "briquets."

In order to meet with popular favor in this country briquets must be of a convenient shape for the shoveling and for the circulation of air in the fire box. They must be of suitable size for the purposes which are intended to serve, and must possess sufficient cohesion to resist fracture and abrasion under rough handling. The very large briquets made in European countries, particularly in Germany, the chief reason for which is the advantage for stowage in bunkers of steamships and tenders of locomotives, are not adapted for use in this country. They must be handled and stowed by hand, and must be broken up before shoveling into the fire. Labor conditions in this country make the cost of such handling prohibitive.

Experience in European countries and the investigations which have been carried on in the fuel-testing plant of the United States Geological Survey, and by the Bureau of Mines, have demonstrated clearly that the successful briquetting of lignite may be accomplished without the use of any additional binding material, and that for the anthracite, semi-anthracite, bituminous, and sub-bituminous coals, the most satisfactory binders are coal-tar pitch, gas-tar pitch, and asphaltic pitch, or inexpensive mixtures of which one or more of these are the principal constituents. The plants in successful operation in this country at the present time have added their experience to the evidence on this point. One plant began operating in 1910, using a binder of which oil obtained from the distillation of wood is one of the constituents, with apparently satisfactory results. Inorganic binders, though efficient in cementing quality, have the serious objection of increasing the ash and of adding nothing to the combustible character of the fuel. Pitch binders, on the other hand, contribute combustible material and do not increase the ash.

### First Recorded Use of Mineral Coal in America

RELYING upon general history, says Charles R. Keys, in the *Engineering and Mining Journal*, the discovery of mineral coal in America dates back to the beginning of the eighteenth century. The earliest record in Pennsylvania is 1704, twenty years after the privilege of colonization was granted by Charles II to Penn. Anthracite was first known in the Wyoming district of Pennsylvania in 1766; and its discovery in the Lehigh Valley took place twenty-five years later. Virginia coals appear to have been mined for the first time near Richmond in 1750; and at the close of the Revolutionary war they were shipped from this region to Philadelphia, New York and Boston.

There are, however, authentic records of the earlier use of mineral coal in this country.

In the Upper Mississippi Valley the earliest definite mention of the existence of mineral fuel in the form of coal appears to be that of the Jesuit missionaries in the Assiniboine land, in what is the State of Minnesota of to-day. As early as 1659, in describing the Poualak (Assiniboine tribes), record is made of mineral coal as follows: "As wood is scarce and very small with them, nature has taught them to burn coal (*charbon de terre*) in its place, and to cover their wigwams with skins." It is quite possible that the Iowa Indians of the northern prairies also made use of the lignite deposits of the region such as are found, for example, in Brown County, Minnesota, near the headwaters of the Des Moines River.

# Physiological Effects of Carbon Monoxide*

## Its Toxicity Has at Times Been Underestimated

By Henry S. Munroe†

An interesting pamphlet on carbon monoxide has recently been issued by the Bureau of Mines, in which attention is drawn to the dangerous properties of this gas and to the use of mice and birds for detecting its presence in mine air. The author quotes largely from various publications of Dr. J. S. Haldane of Oxford University, who for many years has made special study of the subject of mining hygiene and the dangerous gases met in mines. On page 6 the author states: "According to Haldane, carbon monoxide has no other effect than that resulting from its interference with the oxygen supplied to the tissues, and apart from its property of combining with the hæmoglobin it is physiologically indifferent, like nitrogen." The author also outlines an experiment in which he remained for twenty minutes in an atmosphere containing 0.25 per cent of carbon monoxide, "at the end of which time he suffered only a slight headache, although later he became ill. The illness lasted for several hours and was accompanied by nausea and headache." The quotation from Haldane, and this experiment, are likely to give a false impression as to the dangerous properties of this gas; it has therefore seemed wise to give a few facts to our readers, that others may not be led to repeat the experiment made by the author of the pamphlet, and to give some idea of the dangerous nature of this gas even when present in very small percentage.

Carbon monoxide is a product of incomplete combustion. It is present in large quantities in producer gas and water-gas, and in dangerous amounts in the gases from boilers and furnaces of all kinds. It is often present in large proportions, and always in dangerous amounts, in powder smoke, in the gases from underground as well as surface fires, and in the after-damp from explosions of firedamp and coal dust.

Carbon monoxide has the property of forming a compound with the hæmoglobin of the blood. The effect of this is to make the hæmoglobin, so combined, practically inert and to prevent it from acting as a carrier of oxygen. When so much carbon monoxide is absorbed that the greater part of the hæmoglobin is inert, death results. The affinity of carbon monoxide for hæmoglobin is over two hundred times greater than that of oxygen, so that when present in the air, even in small quantities, it is freely absorbed by the blood. Carbon monoxide is not displaced by oxygen, but is dissociated by natural processes, and escapes in the expired air. Where large quantities are absorbed, it may be several days before the last traces disappear. According to Drs. Edsall, v. Jaksch, Haldane, and other authorities, 0.05 per cent of carbon monoxide is dangerous. According to Haldane, severe symptoms were observed from breathing air containing 0.02 per cent, or one part in five thousand. With this small amount present the blood becomes 20 per cent saturated after about 20 hours, producing slight giddiness and shortness of breath. At this point an equilibrium seems to be established, and the dissociation of the gas keeps pace with its absorption. With increasing percentages of carbon monoxide, the saturation of the blood becomes greater and the time required to produce the maximum effect shorter. With 0.08 per cent present, the blood becomes 50 per cent saturated within a few hours; it becomes scarcely possible to stand and even slight exertion results in loss of consciousness, the senses are confused and the judgment is impaired. Sometimes the victim either becomes stupid and drowsy, or much excitement results, not unlike the effects of alcohol. Another experiment by Dr. Haldane proved that with 0.20 per cent CO in the air, the blood becomes 50 per cent saturated in 70 minutes. With 0.25 per cent, the amount present in the Bureau of Mines experiment, this dangerous condition would be reached in less than one hour.

According to v. Jaksch, the absorption of 0.8 gramme of carbon monoxide is fatal. According to Haldane, if death occurs gradually the hæmoglobin is usually about 80 per cent saturated with carbon monoxide. Post-mortem examinations of persons who have died from carbon monoxide poisoning show that the effect is to produce intense congestion of the vital organs, especially in the brain, usually accompanied by small hemorrhages. It is possible that this congestion is due to the attempt of nature to make good the diminished efficiency of the blood by supplying larger volumes at needed points.

Even when death does not occur, very serious results are likely to follow from the absorption of this gas by the blood. The after effects are lesions, cysts and local softening of the brain tissue,[1] inflammation of the membranes of the stomach and intestines, pneumonia, bronchitis, pleural effusions, inflammation of the kidneys, fatty changes in the heart, ænemia, splenic enlargement and other derangements of vital organs, sometimes resulting in death even after several years. It is believed that Sir Clement LeNeve Foster was a victim to carbon monoxide poisoning which occurred on a visit as chief inspector of mines to a mine in Cornwall some years before his death. From the very full record given by Mr. Foster of his symptoms while exposed to the gas underground it does not appear that there could have been more than 0.08 per cent of carbon monoxide present, nor that his blood could have been more than 50 per cent saturated, although direct evidence on both these points is lacking. The experiment made by the author of the paper recently issued by the Bureau of Mines, in which he exposed himself for twenty minutes to an atmosphere containing five times as much carbon monoxide as is known to be dangerous, was therefore hazardous and even though the experimenter apparently suffered but little ill effect a somewhat longer exposure would certainly have resulted in serious injuries, the after effects of which might have proved fatal.

One of the most serious dangers from the presence of carbon monoxide in the air of mines is the effect upon the health of workmen who are daily exposed to the breathing of small amounts of this gas. The blood, when partly saturated, is thereby rendered less able to perform its proper functions, so that the patient suffers from ænemia and all the complications that may result from this weakened condition. According to Dr. Edsall, the disease known as miners' phthisis has been shown to be due chiefly to carbon monoxide poisoning. Recent observations have shown that for some hours after a blast, under ordinary mining conditions, carbon monoxide may be present in the air in dangerous amounts, and undoubtedly men engaged in sinking, drifting, and stopping where the circulation of air is deficient have their blood partially saturated with the poisonous carbon monoxide gas the greater part of the time.

By some authorities it is believed that the serious effects above outlined, due to absorption of carbon monoxide by the blood, are supplemented by direct toxic action on the nervous system, on the muscles, the heart and other organs. It is believed by others that there is a cumulative action and that those who have been poisoned by this gas are more likely to become victims when again exposed to it. It is quite certain that dissociation of carbon monoxide from the blood is slow and that those whose blood is partly saturated will sooner fall victims where larger quantities of the gas are breathed than those whose blood is free from this gas. Men who have repeatedly suffered from carbon monoxide poisoning become very sensitive to the gas, and in most instances are compelled to abandon work in which they are compelled to breathe air containing it.

The symptoms by which carbon monoxide poisoning may be detected are not difficult of recognition. The blood becomes a brilliant cherry red, and in serious cases red or bluish-red spots appear on the front of the neck, on the trunk, thighs and elsewhere, lasting for some days, and in fatal cases apparent after death. The mental disturbances, weakness and lassitude, have been noted. This is followed by headache, accompanied by nausea, often lasting 24 or 48 hours, even in slight cases. In more serious cases, the headache may recur at intervals for some months. Loss of consciousness with convulsions, may occur several hours after the poisoning. One of the first symptoms is weakness in the knees and legs, sometimes lasting for days, with aching from the knees to the ankles. Local pains in the region of the heart, and palpitation of the heart, are common and may recur at intervals for a month or more. Foster, and several others, have published valuable notes on these symptoms, which will be found in the appendix of Foster and Haldane's "Investigation of Mine Air."

[1] In a personal letter, Prof. Walter B. James, of the College of Physicians and Surgeons, states that a peculiar local lesion of the brain, with softening of the lenticular nucleus is fairly characteristic of carbon monoxide poisoning. The action of the gas upon this area has not been satisfactorily explained. It has been suggested that it is due to the peculiar angle at which minor blood vessels are given off to this area from the arterial trunks.

According to Dr. James, the remote consequences of monoxide poisoning are a serious matter. His cases have shown mental aberration of a peculiar type, with great slowness to response, going on to cerebral degeneration and death.

* Reproduced from the School of Mines *Quarterly*.

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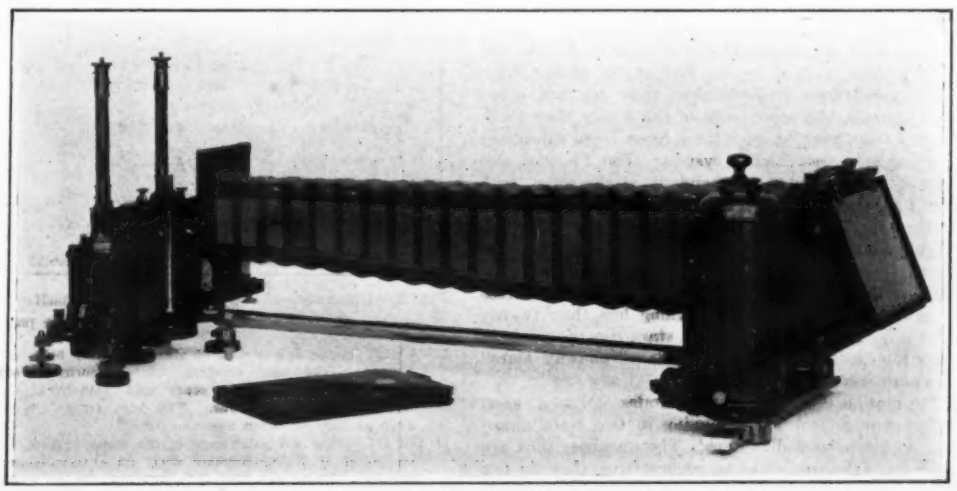
## Apparatus for Determining the Fixed Points of Steel

It is well known that steel exhibits a somewhat anomalous behavior when submitted to temperature changes, the rise or fall of the temperature of the steel lagging behind the heat applied, especially at certain points, known as "fixed points." There appears to be some "change of state" occurring at these points, for just as the temperature of a bath of water containing ice remains constant when heat is applied, until all the ice is gone, so at a "fixed point" continued application of heat for a time produces little or no rise in the temperature of the steel. It is frequently of interest to determine the fixed point of a given sample of steel, and an instrument specially designed for this purpose is shown in the accompanying illustration. This instrument consists of two reflecting galvanometers, so arranged as to throw a spot of light each on the ground glass of a sort of bellows camera. One of the two galvanometers makes a comparative record of the state of the piece of steel under examination, as against a sample of a standard substance having no "fixed points." The other galvanometer indicates the temperature. The instrument is very handy and compact; its general appearance can be gathered from our illustration. The cylindrical body near the ground glass of the camera contains the lamp for the reflecting galvanometers. A plate holder can be inserted in the usual way to obtain a photographic record of the curve traced by the spot of light. Needless to say, the same apparatus can also be used for various other experiments in which temperature is to be recorded.



Apparatus for Photographically Recording Temperature Indications.

# The Origin of the Milky Way*

## The Galaxy Formed by the Meeting of Two Cosmic Systems

By Prof. A. W. Bickerton

THE more we study the stars, the more we are impressed with the fact that the stellar system is not a chance distribution, but on the contrary, that almost the entire content of the celestial vault that we can see, whether it be nebulae or stars, is a single organized system and has a definite boundary.

White, planetary and diffused nebulae; star clusters; temporary, variable and double stars, each and all occupy definite positions, every one of which offers striking evidence of a system of evolution as consistently simple as it is conclusively demonstrated.

Taken roughly as a whole, the Galactic Universe consists of a belt of stars, containing lateral streams, dense aggregations in parts, and equally striking defects of illumination in other parts. This rough ring or belt is possibly of a double spiral character: this opinion is very firmly held by Prof. See and a number of other able astronomers. This belt of stars, which varies from some 10 to 20 degrees in width, is almost exactly bisected by a great circle of the heavens. Leaving the margins of this stellar belt, we come upon two belts of the celestial sphere that are somewhat sparsely inhabited. Then, as we approach the two poles, we meet with an increasing number of nebulae. These seem to have their maximum density in both hemispheres in a position approximately that of the poles of the great circle of the Galaxy. (See Fig. 1.) It is well to look upon this great circle as the equatorial plane of the Sidereal Universe. Many of these nebulae are double spirals. They are, as a rule, what are called White Nebulae, that give continuous spectra, suggesting that they are dust swarms. There are comparatively few stars in the polar regions of the heavens. Stars are mostly confined to the equatorial belt, and it is in this same belt that we find nearly all the gaseous nebulae of the heavens. These vast masses of diffused gas are of two kinds, the one the planetary nebulae, already described. Usually, although very rare, these are extremely definite. The other class of gaseous nebulae, such as the great nebula in Orion (see Fig. 4) is of extreme irregularity, usually quite devoid of any symmetry of form, yet exhibiting marked structure that often seems to suggest drifting motion. In this same Milky Way belt, in addition to gaseous nebulae, are to be found most of the beautiful star clusters. Nearly all the temporary stars have blazed out in this belt, and it is in this same belt that we find most of the variable, or wonder stars, most of the telescopic double stars, and spectroscopic binaries, and here also, although somewhat singularly situated, we find the Wolf-Rayet stars. But very few White Nebulae are found in the belt of the Milky Way. (See Fig. 2.)

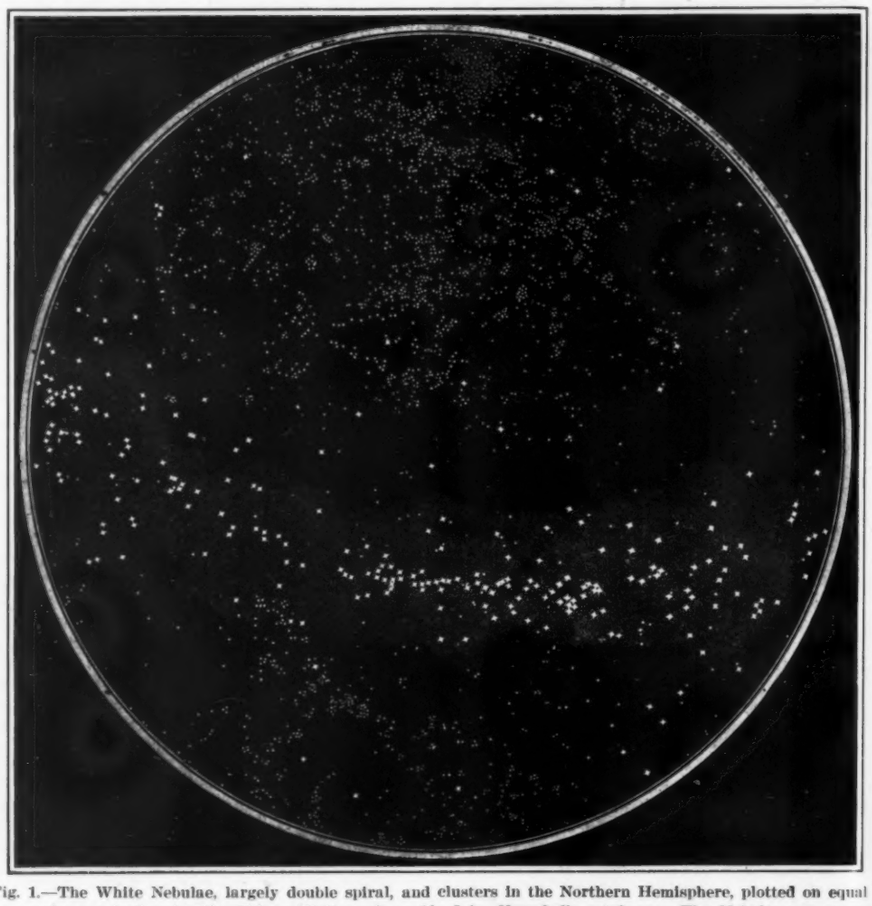


Fig. 1.—The White Nebulae, largely double spiral, and clusters in the Northern Hemisphere, plotted on equal surface-projection by Mr. Sidney Walters, from Sir John Herschel's catalogue. The Nebulae are represented by dots, the Star Clusters by crosses. In this same belt are temporary, variable, double, and Wolf-Rayet stars. This belt is the Milky Way, it contains the bulk of ordinary stars. Identically the same general distribution exists in the Southern Hemisphere.

### INDEPENDENT SIDEREAL SYSTEMS.

In addition to all that has been described, that seem to be parts of one consistent whole, we have other systems of which it is not certain that they belong to our Galactic Universe at all. It is the opinion of Sir David Gill that the great nebula of Andromeda (see figure 5) is a distant Sidereal system not unlike the Galactic system. This opinion of Sir David Gill is shared by other astronomers, who believe that in this beautiful oval patch of light we are looking upon an orderly system of millions of suns. From the brilliant center it possesses it is probably in an earlier stage of evolution than is our own Sidereal Universe.

The exquisite photographs of the Magellanic Clouds suggest that each of these two gigantic systems is an independent double-spiral Sidereal Universe, for spread through each of them we have star clusters, double, and wonder stars, just as in the belt of the Milky Way. Their appearance suggests that they are not much more distant than some parts of the Milky Way itself. Hence, they may at one time have been subsidiary parts of our great Stellar system. The Pleiades also seem to be somewhat independent in character, both from their position as well as their appearance, as shown in Fig. 3. There are other minor systems that also suggest independence. Every star in the entire heavens seems to be moving. The name Proper Motion is given to this independent travel of the stars. It seems to have a mean value of something less than twenty miles a second, but some of the stars rise to speeds of some hundreds of miles a second: "runaway stars" these are sometimes called.

The motion of the stars is not indiscriminate; most of the stars appear to be moving in two stately processions in opposite directions. The distances they are apart are so enormous as to suggest that they do not often collide, but impact is undoubtedly a law of nature, and a surprising number of agencies have already been found that, in spite of the enormous distance of the stars from one another, must tend to produce impact. In addition to these two stately streams a number of minor drifts occur. This, then, is roughly the character of our Sidereal Universe. It will now be our task to attempt to show the mode of its origin. I speak of it as an attempt, but it is more of the character of an induction that has been demonstrated to be true by the fulfilment of endless anticipations based on dynamical deductions. The able mathematician Gifford says: "It has many of its predictions verified by subsequent discoveries in a manner as striking even as the fulfilment of the predictions of Mendelieff, based on the periodic law."

Fig. 2.—Diagram—oblique view—of the constitution of the Galactic System. It is made up of three parts:

I.—A vast double spiral ring of stars. In this belt the dots represent the star clusters, the temporary, variable, double, and Wolf-Rayet stars and planetary nebulae, these last being gaseous. The vast irregular nebulae such as that of Orion are also here.

II and III.—The two polar caps of the same System, mainly composed of White Nebulae with, as a rule, continuous spectra. These are largely double spirals, as shown in the diagram.

### THE ORIGIN OF THE GALACTIC UNIVERSE.

The character of the Milky Way, as seen in the Southern Hemisphere, is much more suggestive of the mode of its origin than the portion we can see on this side of the earth. A centrifugal tendency is most strikingly exhibited. Lateral streamers seem to travel away from the main drift, suggesting the sprays of splashes left by a twirling mop.

It was in the Southern Hemisphere that, probably for this reason, some thirty-two years ago, a study of a beautifully clear sky suggested that the Milky Way was the result of the whirling coalescence of two previously existing independent cosmic systems. A careful study of Proctor's book on "The Universe" aided by Sidney Walter's exquisitely colored charts of the two hemispheres, quickly convinced me that the induction was right; and every discovery made by astronomers since that time has tended to strengthen the conviction, and nothing more strikingly than some very apt remarks made by Prof. Kapteyn, before the Dutch Science Congress, with reference to the Cosmic Cycle,

### THE DYNAMICS OF COALESCING COSMIC SYSTEMS.

Let us try to imagine the dynamical conditions that could bring about a configuration and distribu-

* Partially reproduced from *Knowledge*.

Fig. 3.—Nebulae in the Pleiades, December 8th, 1888.

tion of material similar to the contrasted system that forms the Galactic Universe.

From a consideration of the mode of formation of primordial cosmic systems it has been deduced that they must in all probability consist chiefly of the lighter elements, taken by the high kinetol of the atoms out of cosmic systems. Through this primordial matter denser material is somewhat sparsely distributed. There is a continuous tendency during the whole existence of Sidereal systems for light elements to be expelled. Hence, decadent cosmic systems tend to consist of compact suns, chiefly of heavy elements. Many of these bodies are dark stars, commonly known as dead suns. Thus we have two classes of cosmic systems, the incipient ones, consisting chiefly of light gas, and the decadent, consisting largely of compact masses of heavy elements.

Imagine two such systems to have come within the sphere of one another's attractions. Lateral attractions would prevent the encounter being quite center to center. Thus it is a case of whirling coalescence. As the two systems close in, the one upon the other, an immense friction ensues. The mutual attraction of the advancing suns, aided by this resistance, would cause collisions; a vast central furnace would thus grow up. The field of collision must for ages have gone on increasing both in density and dimensions. The furnace is walled around by the advancing material in all directions in the plane of impact. Presently, as temperature and density increase, the pressure becomes enormous. This explosive matter can find no relief in the plane of impact, for, as already shown, the material of the two vast systems is crowding in all around it and walling it in. But axially there is a chance of escape. The material is ejected toward both poles, and this action goes on increasing in intensity for ages, as the vast masses of the two systems continue to crowd in upon one another. Presently such an enormous quantity of material has been expelled that the capturing power of the third body[1] diminishes. Selective molecular escape expels still more material, and the great central furnace begins to burn itself out. This seems to be the state of the great Nebula of Andromeda, which, as we have said, in the opinion of Sir David Gill, is a system of similar order to our Milky Way.

When axial extrusion occurs it may be pointed out that the capturing power of the third body diminishes, as it does in the formation of orbits of a double star.

Presently the capturing power of the third body lessens so much that the central attraction almost ceases, and the walling-in material is now urged forward by its own onward velocity. The onward motion takes it away from the center, and the great furnace, being no longer fed, will soon have quite burnt itself out. Notice that after pressure ceases to expel material, atomic proper motion will continue to carry away molecules of low weight. This tangential motion carries the material forward in the mode described in the case of double spiral nebulae. The great Milky Way thus gradually spreads itself to the vast dimensions to which it has attained. The dimensions of cosmic systems appear always to be of enormous areas, and consequently the great central furnace would probably occupy but a small ratio of the whole. The two vast systems would be proceeding onward, in opposite directions, outside of the sphere of central influence, and it is this continued original motion that gives us the two majestic streams of stars whose existence has been demonstrated by a number of independent workers.

[1] The central portion formed by the coalescence of the two meeting systems.

Fig. 5.—The Nebula in Andromeda.

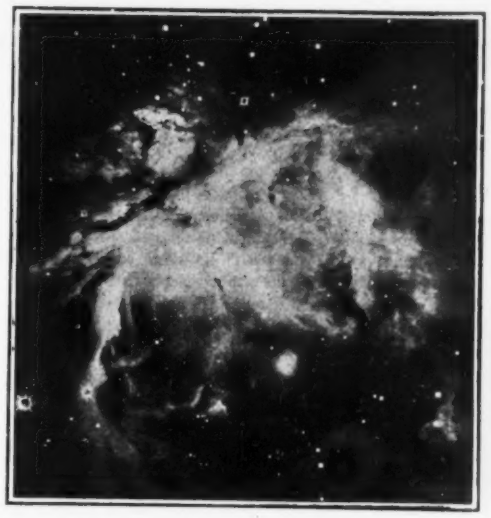


Fig. 4.—The Great Nebula in Orion.

It is probable that every body and system in the universe possesses more or less rotation, and the old cosmic system that, by interpenetrating the primordial, went to the making up of our virile universe, most probably had a rotation of its own; this rotation would continue even during the impact, and it is almost certainly a continuance of this motion that is seen in those great streams of stars that called my attention to the probable origin of the Galactic Universe. There is one very definite principle of impact. It is that all motion developed during the collision tends to regularity, and all previously existing motions tend to disturb this order.

SUMMARY.

This, then, appears to be the mode of origin of the Sidereal Universe. Two cosmic systems of vast dimensions, one primordial and the other mature or decaying, approached one another, drawn together by mutual attraction. They obliquely interpenetrated one another and produced a vast central furnace, from which were expelled the extensive caps of nebulae that now clothe the two polar regions of our sidereal system. This axial extrusion, and selective escape, caused the central furnace to burn itself out; the released centrifugal force carried the walling-in material, stars and so on, to vast distances in space, and formed the Milky Way. In this Milky Way the opposite procession of the two streams of stars, aided by attraction and other agencies, caused collisions of dead and vivid suns, and these collisions produced, as already described, temporary, variable, double, and Wolf-Rayet stars, planetary nebulae and star clusters. The whole of these bodies represent the wreckage of colliding suns, and are all found wherever stars crowd and probably collide. Because these impacts possess such a wonderful building power this theory of impact is sometimes called "the principle of constructive collision."

# Elements of Theoretical Aeromechanics*

## Part II.—Aerodynamics (Irrotational)

By A. F. Zahm, Ph.D.

Continued from SUPPLEMENT, July 13, 1912, Page 31

AERODYNAMICS may be defined broadly as the science of motion of air or an aeriform fluid. Commonly, air alone is implied in the word. This is especially true when the name is used by engineers. With them it is the analogue of hydraulics, which is the science of motion of water. Both sciences treat of not only the motion of their peculiar media, but also of its effect on objects or machinery connected with the fluids.

An important function of theoretical aerodynamics is to determine the velocity and stress of a fluid at every point of the medium when it flows past an obstacle, the physical properties and conditions of the fluid being assumed or given. From the point-velocity the stream-lines may be mapped; from the point-stress about an object the resultant pressure and friction may be found by summing over its surface. Equivalent results may be obtained if the object is assumed to move against the fluid, since only the relative motion is of consequence. This is regarded as self-evident.

It will be convenient to treat of aerodynamics together with the general science of fluid dynamics.

*Abstracted from the author's forthcoming popular treatise on aeromechanics.

Theoretical fluid dynamics, being a difficult subject, is, for convenience, commonly divided into two branches, one treating of frictionless or perfect fluids, the other treating of viscous or imperfect fluids. The frictionless fluid has no existence in nature, but is hypothecated by mathematicians in order to facilitate the investigation of important laws and principles that may be approximately true of viscous or natural fluids. We may first notice some of the principles and conclusions in this easier branch, then pass to the treatment of viscous media.

DYNAMICS OF FRICTIONLESS FLUIDS.

*Stream-lines and Vortex-lines.*—The motion of a fluid may be rotational or irrotational, and each of these kinds of flow may be steady or unsteady. The motion of the medium is irrotational if every part of it moves with fixed orientation, so that if a small sphere of it were suddenly frozen it would drift along without rotating in any direction; otherwise the flow is rotational. The motion of the fluid is steady when its velocity at every point of the stream is constant in magnitude and direction.

In all kinds of movement the translational velocity of the fluid may be everywhere manifested by means of stream-lines; that is, lines drawn everywhere in the medium in the direction of flow of the coincident fluid. Each particle of the fluid, therefore, moves in the direction of the instantaneous stream-line passing through it. Evidently such lines are stationary in steady motion, but shifting from instant to instant in unsteady motion. In the latter case they are called lines of flow by some writers. In like manner lines may be drawn everywhere through a fluid in rotational motion, showing the direction of rotation of its small parts, and serving, so to speak, as axes of rotation for the fluid particles strung along them. These are called vortex-lines. In this text, however, none but irrotational motion of the fluid, or body immersed therein, shall have consideration.

The stream-lines are of great importance in the science of fluid dynamics and its practical applications to the flow of air and water. They not only mark the direction of flow at every point of the medium, but also fairly indicate the translational velocity of the fluid at each point, particularly if there be little change of bulk of the flowing particles; that is, slight expansion

or contraction. A simple example will illustrate this.

Suppose a pipe of varying cross-section to convey in steady flow a liquid, or a gas, at practically constant density. Then, since the same amount of fluid per unit time passes through all segments of the pipe, evidently the flow is swifter through the narrow sections than through the broad, the average velocity at each part of the pipe being inversely as the cross-sectional area of that part. But if various stream-lines are drawn in the current they will crowd together in the narrow parts of the pipe and separate in the wider parts, thus showing the relative speed of flow from point to point, as well as the direction. Furthermore, stream-tubes may be drawn in the current, their walls being composed of stream-lines, or, say, delineated by them; and at every part of any such stream-tube, supposed very narrow, the velocity of flow is inversely as the sectional area of the tube at that part. But since the longitudinal sections of the stream-tubes portray the stream-lines, these latter may in many cases fairly indicate the velocity of the current, being near together when the current is swifter, and *vice versa*.

*Principle of the Conservation of Energy.*—Now, as any given particle, or small mass of fluid, moves along stream, its bulk, pressure, and level may change, as well as its velocity. Thus work may be spent upon the particle, both by gravity, in accelerating it, and by the surrounding fluid pressure, accelerating or compressing it. Hence, in case little or no compression occurs, *the work of gravity and pressure together equal the kinetic energy communicated to the small mass of frictionless fluid, in speeding it along its stream-line in the steady current.* This is "Bernouilli's Theorem"[1] on the flow of liquids, here proved on the assumption that a particle of fluid can have an increase of its total energy only from external agencies, and by no means of its own; or, in other words, that a material system cannot increase its own energy, which is but a statement of the well-known principle of the conservation of energy.

Bernouilli's theorem is much used in the practical applications of fluid dynamics in science and engineering, both in its more general form, as above, and in simpler forms. Some of these will follow by way of illustration. But first we may notice the quantitative relation between speed and pressure at any point along a stream-line.

In case of horizontal flow the particle is accelerated along stream solely by the difference of fluid pressure on its front and rear. Thus it gains speed in the direction of waning pressure, so that where the pressure is least the speed is greatest, and the stream-lines are closest together. This obviously is true also of downsloping stream-lines, since here the component of gravity aids in speeding the particle. It is true in upsloping stream-lines if the fall in pressure more than compensates the retarding influence of gravity. Hence, in steady motion the stream-lines, besides accurately indicating the velocity and direction of flow, fairly indicate also the pressure.

The stream-line manifestations are very instructive where they can be practically observed, either on a diagram or in a liquid or gaseous current rendered visible by means of pivoted vanes or drifting particles. Where, for example, a current flows squarely against a disk well submerged, the stream-lines bend symmetrically round the disk, crowding together toward its periphery, but widening near the center of the disk, thus disclosing the fact that the unit pressure is greatest at the center of the disk and least at the periphery. Again, if a fluid flows from one large chamber to another, through a narrow straight, the stream-lines crowd together in the passage, showing there increased velocity and diminished pressure.

To find the quantitative relation between the pressure, depth, and speed, in a frictionless fluid of given density, we may equate the gain of kinetic energy of a small unit cube of the fluid to the work done upon it by gravity, plus the work done by the difference of pressure on its front and rear faces in accelerating it along stream. Taking each in turn, we note, first, that the gain of kinetic energy of the unit cube equals one-half its mass times the gain of its velocity square; secondly, that the work of gravity equals the weight of the cube times its change of level; thirdly, that the work of the difference of pressure on the front and rear of the cube, in pushing it from one point to any other point in its path, equals the difference of hydrostatic pressure at these two points. To prove this third affirmation observe that while the unit cube moves once its own length the pressure-work done upon it equals the difference of pressure fore and aft multiplied by one unit length of displacement; then, as it moves again its own length, the work done equals the new pressure difference multiplied by unit length of displacement, and so on as the small unit volume traverses successive lengths of itself along any segment of the stream-line. Summing all these successive products of the pressure difference by the common unit length gives simply the total pressure difference between the first and last position of the moving particle, as a measure of the work spent by the pressure difference on the front and rear faces of the unit cube in speeding it along stream and increasing its kinetic energy. This is obviously true when the cube of incompressible fluid changes length in moving along the stream-line; for a change of length means a corresponding change of cross-section, thus leaving the resultant pressure difference on its front and rear faces the same, assuming the pressure gradient along stream to be finite. Equating the first work-quantity to the second plus the third, gives the analytical relation sought. This relation may obviously be generalized to cover elastic media, by writing the work of pressure and gravity equal to the gain of kinetic energy plus the work of compression.

In order to translate this verbally expressed relation into a symbolic formula, or equation, let $\rho$ be the constant mass of the fluid particle, taken as a unit cube; $z_1$, $z$, its initial and final distance above any fixed level; $p_1$, $p$, the initial and final pressure on its face; $v_1$, $v$, its initial and final velocity, as it traverses any segment of a stream-line. Then the above verbal expression generalized may obviously be written:

$$(p_1 - p) + g\rho\,(z_1 - z) = \tfrac{1}{2}\rho\,(v^2 - v_1^2)$$

in which the first term is the difference of pressure at the ends of the assumed course of the particle; the second term is the work of gravity upon the particle, being its weight times its change of level; the third term is the gain in kinetic energy, being one half the mass times the increment of the velocity square. This equation is Bernouilli's analytical expression connecting $p$, $z$, $v$, $\rho$, the variable pressure, depth, and speed of a fluid particle, the other symbols representing fixed and given quantities. A few simple examples will show its usefulness, beginning with incompressible fluids.

Let it be required to find the speed in a horizontal stream of water, or of air, at practically constant density, starting from rest in a chamber at constant pressure $p_1$, and flowing steadily through a narrow channel into another chamber at constant pressure $p$. Since the fluid starts from rest $v_1 = o$, and since the flow is level $z_1 = z$; thus Bernouilli's equation gives $v^2 = 2\,(p_1 - p)/\rho$. As, in this expression, all the quantities except $v$ are given, the velocity is determined.

In case the initial pressure, in the foregoing example, is due solely to the weight of the fluid, as in a large tank of liquid *in vacuo*, if $h$ be the depth of the narrow straight or aperture, $p_1 = g\rho h$; and if the flow ends *in vacuo*, $p = o$; so that Bernouilli's equation for this simple case is $v^2 = 2\,g\,h$. This value of the velocity of discharge is the same as that of a body falling freely through the height $h$; and, if the discharging stream be directed upward, the fluid will rise to the level of its free surface. This interesting relation, deduced so simply from Bernouilli's theorem, as a very specialized case, was first discovered experimentally by the philosopher Torricelli, and is commonly known as *Torricelli's Theorem*, published by him in 1643.

The above deductions from pure theory—that is, from the mathematical analysis of the flow of a frictionless, or hypothetical, fluid—have been tested experimentally, and found to give satisfactorily the velocity of such natural fluids as air and water under simple conditions. The writer[2] in 1902, and Eiffel[3] in 1909, made a careful test for the first medium, by measuring the speed of influx of air from a room into a chamber at reduced pressure and at all speeds up to more than twenty-five miles an hour, and found the computed speeds to agree closely with the observed ones. The speed of efflux of liquids has been carefully determined many times since the day of Torricelli, sufficiently corroborating his conclusions for all but extreme conditions. It may be said that, for both cases cited, the speed of efflux is slightly less than for a perfect fluid—commonly one or two per cent less—owing to the loss of kinetic energy by friction as the fluid particles rub the channel wall, or crowd and deform each other, thereby doing internal work. Of course, for long and tortuous passages the formula is inapplicable to natural fluids, because of friction.

It is important, also, to note that the argument by which Bernouilli's theorem was deduced may be worded so as to apply to a fluid mass spending its kinetic energy in overcoming gravity and the difference of pressure, front and rear, as it flows along stream to points of higher level and pressure. While the wording will be reversed, the symbolic expression, or equation, will remain unaltered, since the symbols as they stand are perfectly general, and apply to both accelerated and retarded flow. This generality adds to the usefulness of Bernouilli's theorem.

Suppose, for example, that a horizontal jet or current of air or water strikes squarely against a flat surface, and it is required to find the unit pressure of the fluid at the center of impact. At this point the speed $v = o$, while in the unchecked stream $p_1 = O$; and everywhere $z = z_1$, so that Bernouilli's equation gives $p = \rho\,v^2/2$ as the pressure at the center of impact. Thus, if it struck into a hole in a tank, it would, since $p = \rho\,g\,h$, balance a fluid practically of the height $h = v^2/2g$ of the fluid above the aperture, or the "height due to the velocity."[4] This has been proved experimentally. As an instance, the reader may be referred to Mr. W. M. White's paper, "The Pitot Tube: Its Formula," published by the Association of Engineering Societies, under date of August, 1901.

The formula $p = \rho\,v^2/2$, found for central impactual fluid pressure, is made the basis of the pressure tube anemometer and hydrometer, instruments for measuring the speed of flow of air or water, and commonly called the Pitot tube, after Pitot, who first devised it. If an open-mouthed tube is held along stream—in water, for example—so as to receive the full impact of the current, and if the resulting increment of pressure in the tube is measured, the velocity can be accurately computed from the foregoing formula $v^2 = 2\,g\,h = 2p/\rho$. In like manner, if the excess of pressure of the wind blowing squarely into the tube, as compared with the pressure in the unchecked wind, is observed, the wind-speed can at once be calculated by the same formula.

Many other examples may be proposed and worked out to illustrate the use of Bernouilli's equation for the steady motion of a frictionless incompressible fluid, and its application to the flow of natural liquids and gases, under conditions involving only slight friction and change of density; but these may be left to the reader's fancy or requirements. Further treatment, also, of these interesting questions may be found in any thorough book on hydrodynamics, such as the elegant English treatise of Prof. Horace Lamb.

When considerable compression or expansion occurs in the moving fluid, Bernouilli's equation may still be applied, but only in its more generalized form containing a fourth term, which expresses the work done in altering the bulk of the unit cube of the fluid. In practice the equation is divided by $\rho$, so that the fourth term is the work done in compressing the volume of unit mass of the fluid. But this change of bulk may follow any one of a myriad laws of expansion. Usually some law is given or assumed. Thus, the expansion or compression may occur at constant pressure, constant temperature, constant heat content. If the pressure is constant the work of compression is obviously $p\,(V - V_1)$, or the pressure times the change of volume of the unit mass; and hence this expression, or its equivalent $p\,(1/\rho - 1/\rho_1)$, must be used as the fourth term in Bernouilli's more general equation. If the flow occurs at constant temperature the work of compression is $R\,T\,log\,(p/\rho_1)$, in which $T$ is the absolute temperature, and $R$ is a constant for the fluid. This expression, as also the one for the work done in adiabatic compression, may be found duly derived in any adequate treatise on heat-motors, or on thermodynamics or hydromechanics. The formulæ need only be referred to here, being too abstruse for the present treatment.

To be continued.

**The Consumption of Food in Paris, 1911.**—The following statistics, lately published by the Prefecture of Police, which controls the markets of Paris, gives the quantities of some of the principal articles of food brought to the Halles Centrales last year as compared with those of the previous year:

| | 1910. | | 1911. | |
|---|---|---|---|---|
| | Metric Tons. | English Tons. | Metric Tons. | English Tons. |
| Meat | 56,797 | 55,902 | 54,763 | 53,900 |
| Poultry and game | 23,607 | 23,235 | 22,255 | 21,904 |
| Fruit and vegetables | 46,157 | 45,430 | 59,535 | 58,597 |
| Butter | 15,076 | 14, 38 | 13,921 | 13,702 |
| Cheese | 14,605 | 14,375 | 12,828 | 12,626 |
| Number of eggs | 312,524,000 | | 300,868,000 | |
| Number of vehicles engaged in bringing produce to market | 234,000 | | 327,000 | |

Although a considerable falling-off is noticeable in the quantities of meat, butter, cheese and eggs brought to market last year as compared with those of 1910, the supply of vegetables was considerably larger. The amounts realized by the sales of produce in 1911 were also greater.—*Journal of the Society of Arts.*

[1] Daniel Bernouilli, "*Hydrodynamica Argentorati*," 1738.

[2] "Measurement of Air Velocity and Pressure," *Physical Review*, December, 1903.

[3] "Resistance de l'Air et l'Aviation"

[4] The height due to the velocity is the height to which a free body rises when started vertically upward with the given velocity. It is commonly called the "velocity head."

# The 1912 Convention of the Master Mechanics Association

## Discussion of Many Important Points in Railway Practice

By Reginald Gordon

THE forty-fifth annual meeting of the American Railway Master Mechanics' Association was held at Atlantic City, N. J., June 18th, 19th and 20th, 1912. The reading and discussion of the reports not only brought out a large amount of information on subjects of vital interest to the mechanical officers of railroads, but also settled some questions concerning which inconclusive results had hitherto been obtained. The president of the association, Mr. H. T. Bentley, in his address to the convention, after reviewing the progress of locomotive development during the past year, dwelt upon that aspect of the subject of conservation which appeals to the railroads, namely, fuel economy, the reduction of transportation costs by the use of larger and more powerful locomotives, and the best means of diminishing injuries and loss of life. He suggested the enactment of a federal law forbidding trespassing on railroad property, citing the fact that in the United States more than 5,000 persons are killed annually as the result either of walking on tracks or riding on trains on which they do not belong. The president referred also to the legal requirements of high power electric headlights for locomotives in the State of Mississippi, and stated that the legislatures of Kentucky and Louisiana had failed to pass a similar bill introduced during the last session, in spite of the fact that much pressure was brought to bear in favor of its passage. He emphasized the different conditions prevailing on single track, and upon multiple track roads; on the latter of which, especialy when equipped with block signals, the electric headlight is objectionable and dangerous on account of the confusing glare produced.

One of the most important topics considered by the convention, and one on which the committee was continued from the 1911 meeting, was that on mechanical stokers for locomotives. Two general types, the overfeed and the underfeed stokers, have been put into extensive use during the past year, and valuable experience concerning them has been obtained. In both types, the coal must be crushed to the size that will pass through a 1½ inch mesh, before being fed on the grate or discharged above the fire. The necessity for this complicates the mechanism by increasing the number of parts to more than those required if the tender could be supplied with crushed coal, ready sized. In the operation of both kinds of stokers difficulties were met at first, owing either to bad design, poor construction, or insufficient fastening of the stocker apparatus to the boiler and tender; but after these faults were understood and remedied, there was very little trouble in actual service. It has been found to be possible to work the large lococmotives that have recently come into service at a rate more nearly up to their full capacity by the mechanical stoker; and it has been found possible to feed 11,000 pounds of coal per hour by one of these machines. When it is realized that the best average performance by a fireman in regular work is the shoveling of about 5,000 pounds of coal per hour for from three to four hours at a stretch, it will be understood what an enormous gain is secured in the capacity of a large modern locomotive when it is fired mechanically. A careful study of the results of the operation of the engines equipped with this new device, show that though they burn much more coal than can possibly be supplied to them by human labor, they actually reduce the cost of hauling large, heavy trains per ton mile; because the full capacity of the boiler can be thereby utilized. Several members testified that mechanical stokers can be operated so as to reduce black smoke when the engine is working hard. The determination of these facts is regarded as a long step in advance, and it was generally agreed that in heavy service, both freight and passenger, the mechanical stoker has come to stay.

Another topic on which a committee had continued at work from the previous convention was that of the maintenance of locomotives using superheated steam. Five years ago there were not more than ten or twelve locomotives equipped with superheaters running in the United States; although in Canada Mr. Vaughan, of the Canadian Pacific, was experimenting on several kinds of superheaters applied to a number of his engines. At the present time, more than 2,200 superheaters, nearly all of the fire tube type, are in use in the whole of North America; and the majority of railroad officers who have tried them speak enthusiastically in their favor as giving a locomotive additional power and effecting marked savings in fuel, water and boiler maintenance. When properly installed, carefully inspected, and well maintained, there is an actual saving of fuel of from 20 to 25 per cent, and a saving of water of 10 to 15 per cent as compared with saturated steam locomotives of the same type in the same kind of work. On one road in particular, the master mechanic has secured a 25 per cent economy of fuel, together with an increased tonnage rating of 10 per cent greater than that for this class of engines when using saturated steam. Some difficulty, however, has been experienced in lubricating the valves and cylinders of superheated steam locomotives, as many oils carbonize at the high temperatures, and rod packing must be renewed more frequently. Experience has shown that it is impracticable and uneconomical, for various reasons to use steam heated more than 100 deg. Fahr. above the temperature corresponding to the pressure, whether this be 160 or 200 pounds per square inch. For satisfactory results, the temperature of superheated steam should not be higher than 600 deg. Fahr. It has required patient experiment and careful observation to ascertain the best kind of oil to employ for lubricating valves and cylinders and the most advantageous location for introducing it into the steam passages; and to discover the metal best adapted for use in valve bushings and for piston and valve rod packings. Opinions freely expressed by master mechanics at the convention lead to the conclusion that these difficulties are being rapidly overcome, and that the use of superheated steam will soon be so common as to be regarded as standard practice. Furthermore, superheated steam and mechanical stokers are justifying the construction of the enormous locomotives of the Mallet, Mikado and Mountain types that have been put to work on our principal railway lines during the past year.

A complete and detailed report was presented on the design, construction and inspection of locomotive boilers. This covered prevailing practice in regard to those parts of a locomotive boiler that are usually the most troublesome to maintain properly, such as firebox foundation rings, stay bolts, door openings, etc., as well as the proper method of setting and tightening flues and the proper number and location of washout plugs and hand holes to facilitate inspection of the inside of the barrel and water legs. There were some differences of opinion regarding the last, some members recommending a distance as great as 7 inches between inside and outside firebox sheets, while others stated that they got better circulation of water and quicker steaming by having the water leg only 4 inches wide. The merits and disadvantages of combustion chambers between the grate and back tube sheet were also discussed at some length. The prevailing opinion favored the use of combustion chambers, with certain kinds of coal, and where frequent inspection and washing out of water legs was possible. It was also stated that with good firing, the combustion chamber prevented the formation of black smoke to a considerable degree. The recommendations as to the best size and length of flues, and the methods of making the same tight in the sheets were valuable; as were the opinions expressed regarding superheater tubes, which are usually 5 inches in diameter, and present difficulties in setting and maintaining that most boiler makers employed on locomotive work have never been called upon to face. Recognition of the relative value of firebox heating surface compared with that in the tubes has led many locomotive designers to discourage the use of tubes longer than 16 feet; and to advocate combustion chambers in boilers demanding a greater tube length than this.

Many opinions were secured, representing the vast majority of railroads, concerning safety valves. Many roads specify that locomotive builders shall apply three safety valves to large boilers, while others require only two, holding that two valves, inspected and tested at regular intervals are sufficient. Many safety valves become unreliable owing to corrosion of the spring and valve seat; others are designed so that they have insufficient lift, and consequently do not relieve the pressure fast enough. Some experience has been obtained with nickel seats, this metal being regarded as best adapted to resist corrosion; but the tests have not been conducted far enough to determine its ultimate merits for this purpose. It was, therefore, recommended that for the present, bronze alloys should continue to be used.

The committee on steel tires presented a summing up of the prevailing practice in the composition of steel to be used for that purpose, and recommended to the convention that there should be three classes of tires, graded for different kinds of service by the percentage of carbon contained: No. 1 having from 0.5 to 0.7 of one per cent carbon; No. 2 from 0.6 to 0.75, and No. 3 from 0.7 to 0.85 of one per cent. In all three classes the phosphorus and sulphur must not exceed 0.05 of one per cent each, and manganese 0.5 to 0.8 of one per cent. Class 1 includes tires for driving wheels on passenger locomotives; No. 2, tires in freight service, and No. 3, those for switch engines and all truck and trailer wheels as well as those for tender trucks. This method of grading steel tires is extensively used, but action on the matter was deferred until another year, as many members were not satisfied that the specifications met every requirement of service.

In somewhat the same line, there was an animated discussion over the report of the committee on contour of tires. A tapering tread, at the rate of 1 in 20, with the outer edge rounded off, was recommended; and as some members were strongly in favor of straight or cylindrical, as opposed to conical tire treads, the opposite views were hard to reconcile. It was also suggested as the result of experience on a number of roads, that the standard height of flange be 1¼ inch for road engines, and 1 inch for yard engines. It was decided to submit these questions to letter ballot by the members.

At the 1911 convention, many members stated that they had had disappointing experiences with main and side rods of fluted or I-beam section; and the opinion was expressed that this was due to lack of uniformity of the metal. Where insufficient forging is given, the most thoroughly worked metal is on the outside of the rod; and this is the very steel that is cut away when the groove is milled out on each side, leaving non-homogeneous, defective steel in the web of the rod. It is recommended that rods be more carefully forged to insure better material all through; and that designs shall be based strictly on a formula presented by this year's committee for the calculation of stresses in all classes of rods. In this way it is hoped to entirely eliminate breakage in service.

Another topic carried over from last year's meeting was that of flange lubrication. From the results obtained by the use of devices for lubricating driving wheel flanges, railway men appear to be in favor of them as effecting a decrease in the cutting or sidewear of flanges, a detail of maintenance that often sends an engine to the shop to have its tires turned up before it may need any other repairs. For a lubricant, crude oil sprayed against the flange by air pressure is extensively used, while graphite mixed with grease is reported by some to give good results. Roads using electric locomotives are well satisfied at the diminished flange wear resulting from their use; and in several cases, on crooked roads, it is said that the life of rails on curves is greatly lengthened thereby.

The association also went upon record as opposed to high power electric headlights for locomotives, especially on block signaled roads, and on those having three or four tracks. The glare of such lights makes it difficult for the runner of a locomotive running in the opposite direction to distinguish block and train order signals under the most favorable conditions; and in a foggy or smoke-filled atmosphere the difficulty is much increased.

No account of the recent railway conventions would be complete without a reference to the exhibit made by the manufacturers of railway supplies and appliances at Atlantic City during the meetings. Raw material, complete, full size parts and devices representing the most advanced practice, as well as many high efficiency machine tools were shown; and in many cases, actual demonstration of the capabilities of the latter could be made. Not only all the important details of interior furnishing and illumination were shown, but actual specimens, ready for use, of wheels, axles, springs, bolsters, trucks, etc., as well as boiler tubes, rivets, and staybolts. A careful examination of the exhibits, together with the consideration of the reports and discussions at the meetings gives one an excellent idea of the latest progress of mechanical engineering on railroads, as well as the development of the art of electric lighting for trains.

All in all, the convention of 1912 must be said to have been most fruitful in bringing to the front of our attention many matters of the greatest importance in railway practice, and furnishing an opportunity for their discussion by the men best fitted to pass judgment on the questions involved. It may be hoped that practical results will soon follow.

Fig. 3.—The Pontoon at Work Paying Out the Cable Over the Drum.

Fig. 4.—Pontoon Withdrawn and the Cable Ends Supported on Small Boats.

# Laying Out a Cable System Through the River Trave

## For High Tension and Telephone Transmission

By Our Berlin Correspondent

THE crossing of rivers and lakes by cables doubtless belongs to the most difficult operations met with in electric installation work. Difficulties already begin in planning the plant, and in estimating the cost which is influenced to a high degree by local conditions, the depth and condition of the bottom, rate of flowing of the water and other factors. Even if these have been carefully and accurately studied, they undergo changes before operations are actually begun.

The main difficulty of the operation is due to the necessity of avoiding any injury to the cables in lowering them into the river or lake and of insuring their proper arrangement at the bottom at convenient distances apart.

When erecting the Lubeck power transmission plant it was necessary to cross the River Trave near Lubeck with a number of cables, viz.:

Two 6,000-volt high-tension cables of $33 \times 0.007$ square inches and cross sections 525 feet in length.

Two 700-volt low-tension cables of $3 \times 0.054$ square inches and 426 feet in length.

A 10-strand telegraph cable 426 feet in length.

A telephone cable 525 feet in length.

These cables were covered with a heavy wire armature, rendering them sufficiently resistant against any tractive strain and protecting them against damage. Fig. 6 represents a cross-section of the high-tension cable, and Fig. 8 a cross-section of the telephone cable.

The two high-tension cables, the telegraph cable as well as the telephone cable were each wound on a special drum, whereas the two low-tension cables were carried by one single drum. The weights of the cables and drums were:

| | |
|---|---|
| High-tension cables ..... | 2,373 kilogrammes |
| Low-tension cables ..... | 2,163 kilogrammes |
| Telegraph cable ..... | 980 kilogrammes |
| Telephone cable ..... | 972 kilogrammes |

The width of the water level at the point where the cables were to be laid out is 80 meters, the maximum depth of the river being 12 meters. A groove 6½ feet in depth and 33 feet in width had been dredged out for the cables, this considerable width being rendered necessary by the unfavorable conditions of the river bottom.

Fig. 5.—Diver Emerging After Inspection of Cables.

Fig. 3 shows to the left the two low-tension cables wound up on a drum. The two cables, guided by round timbers, were made to slide over slanting round timbers into the water. The two high-tension cables and the telephone cable were let down into the river over a large pulley installed in the middle. The telegraph and low-tension cables were guided by round timbers. Anchors connected by a chain were cast to the right and left respectively of the groove to moor the cables to the river bottom, each cable being fixed to the chain by ropes wound around it.

In unwinding the cables the pontoon was slowly hauled over by two capstans installed on the opposite bank of the river (Figs. 2 and 7); being fixed to the anchored chain, the cables had to slide into the groove dug at the river bottom.

The pontoon was prevented from turning or drifting by anchors cast on both banks at about 100 feet distance from each side of the groove, with which the pontoon was connected by slack ropes. A flagstaff was fixed in the middle of the pontoon and those superintending the operation from the riverside would take care to keep the flagstaff in the center of the cable groove, the position of the pontoon being adjusted by tightening or slackening the ropes (Fig. 7). Such slack ropes are, of course, arranged in accordance with local conditions, being fixed, in the present case, to ice breakers or to barges moored in the river.

The operation of drawing the pontoon from one bank to the other occupied two hours. Care was taken throughout this time—by braking each cable drum more or less strongly—to have each drum unwind its cable uniformly, the distances between each two cables being kept constant.

After the pontoon had reached the opposite bank (Fig. 1), the cable ends were taken off the drums and carried ashore. The cable sections protruding out of the water having then been supported by two small boats coupled together (Fig. 4), the pontoon was withdrawn from beneath the cables.

By pulling each cable from the riverside and dropping it from the boat into the water, its proper position in the dredged groove was insured also at the other bank. A diver (Fig. 5) went down to the river bottom after the operation had been completed, to insure that there was nowhere a crossing of high-tension cables with low-tension or telephone cables. After he had made sure that the position of the cables below water was quite irreproachable, the cable groove was filled in with sand.

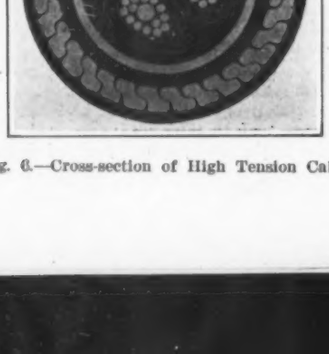


Fig. 6.—Cross-section of High Tension Cable.

Fig. 7.—Pontoon Being Drawn Across the River While the Cables are Deposited on the Bottom.

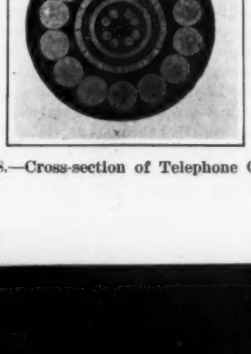
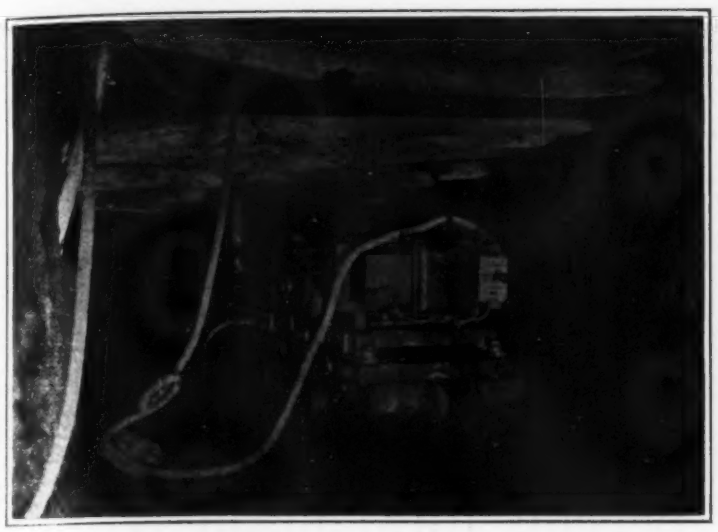


Fig. 8.—Cross-section of Telephone Cable.



Portable Track Pump and Motor on Bogie at Whitecliffe Mine.

Five Horse-power Motor Driving Rock Drill.

# The Electrically Operated Loftus Ironstone Mine

## A Representative of Up-to-date Practice in Great Britain

In Yorkshire, England, about four miles from Saltburn are situated the Loftus ironstone mines consisting of two adits driven in the hillside on the east of the deep valley dividing Loftus from Carlinhow. The drift which extends in a southeasterly direction, is operated by a steam hauling engine at the surface, which serves three different districts; first the Whitecliffe mine, lying underneath part of the township of Loftus; second the Loftus mine proper, farther to the north; and third, the Grinkle mine some two miles distant.

The electrical equipment has been installed at this south drift, while nothing in the way of electrification has been done with the north drift. The Whitecliffe engine plane and the various districts are operated by electricity, and there is an electrical equipment for underground haulage. The electric hauling engines were required to be placed so that the lead of the rope should be as straight as possible and so arranged that either electric haulage equipment could relieve the other in case of breakdown or stoppage. The in-bye haulage roads meet at the bottom of the drift from the surface and at this point the ropes from the two haulage systems cross. The endless rope haulage system is operated by an electric motor driven haulage gear with rope transmission. There is a direct connected electric equipment in No. 4 haulage room and a rope driven electric installation in No. 5.

The electrical equipment of the Loftus ironstone mines is interesting for it includes a number of rotary electric drills, each of which is capable of boring 30 holes from 3 to 4 feet in length and 1½ inches in diameter per hour. It does this work continuously, each electric drill carrying its own supply of trailing cable on a special drum fitted with a sliding contact. The drill carriage is provided with regulator and starting switch. The electrically driven drainage pumps in use are of unique construction, being of the ram type and delivering their water to the sump which supplies two centrifugal pumps. The portable electric drainage pumps are provided with direct-geared motors, one of them being capable of delivering 50 gallons per minute and the other 30 gallons. They are readily moved wherever desired, the electric switches being mounted on the pump framework together with the starting resistances. A direct current is employed for operating the pump motors as well as those of the electric drill.

In the centrifugal pump room there are two electric motors, each of 85 horse-power capacity, directly coupled to rotary pumps which deliver 600 gallons of water to the surface per minute against a head of 300 feet. These pumps are run alternately. The motors are started by means of liquid switches and each pump set is provided with a switch column consisting of a double pole switch with circuit breaker and ammeter, the whole being iron clad and fire proof.

In addition to the pump and drill operated by continuous current from the gas engine power plant, direct current is also used for the endless rope haulage room which is equipped with a 100 horse-power multipolar motor designed to operate at a speed of 525 revolutions per minute. This electric haulage gear consists of two rope wheels each 6 feet in diameter arranged to run at a speed of 7 revolutions per minute, thus giving an approximate speed of 1½ miles per hour on the rope. The entire electric equipment of the Loftus ironstone mine was constructed at Gateshead-on-Tyne, England, and is considered to be representative of the most up-to-date practice in Great Britain.

For haulage service, electric power is obtained from a sub-station at the mine located near the power house, this sub-station receiving electric current from the Cleveland and Durham electric power company. On account of the intermittent nature of the load on the haulage roads of this mine, electric power was obtained from the power company named, while a gas engine electric power house was installed at the Loftus mines for operating the centrifugal pump, the electric driven drainage pumps, the electric drills at the face and for electric lighting underground as well as at the surface. This power station at the mine also supplied the necessary electric current for the Whitecliffe mine in this rope haulage service.

There are three four-cylinder vertical gas engines of the Campbell type constructed at Halifax, England, in the Loftus mine power plant. Each of these vertical gas engines is directly coupled to a generator of 230 kilowatts capacity, supplying a direct current at a pressure of 550 volts. The gas engines are operated by gas from three suction producers from Durham Coke breeze obtained from the colleries of Pease & Oartners, Ltd., who also own the Loftus mines. The continuous current from the gas engine power station was used for two years for driving the haulage gear which was originally operated by a horizontal steam engine in No. 5 haulage room.

This plant consisted of a 250 horse-power direct-current motor, operated at a normal speed of 375 revolutions per minute and regulated by means of a controller of the railway type with iron grid resistances. On account of the unavoidably intermittent nature of the load, the voltage of the whole system of direct-current electric lighting was affected every time the rope driven haulage gear was started. This caused also irregular working in the gas engine power station, and, to overcome the difficulty, the motor was placed on the three-phase circuit of the power company. The high tension current was conducted down the drift by a three-core cable of 0.15 square inch area which was laid solid under the traveling road. From the junction of these cables at the distributing board, smaller cables were led to the No. 5 haulage room, each having an area of 0.075 square inch. The current was conducted through these cables to the present three-phase motor of 250 to 300 horse-power capacity, which also in case of necessity does the work usually handled by the No. 4 electric haulage plant. The motor is wound for 2,750 volts, a frequency of 40 cycles per second and operates at a speed of 347 revolutions per minute. In the No. 5 haulage room, this motor drives the haulage gear through an intermediate shaft by means of cotton rope. A metallic controller of massive construction is in service. This controller has three sections each having 15 stops, with one section for each phase. There is a quick brake switch with a positive action for each stop and in addition a spring brake so arranged that in case of the spring failing, the switch will still be effective. In this controller, each stop is connected by an insulating cable to an elaborate series of resistances installed in galvanized iron tanks three in number, one for each phase and filled with oil of high quality. The tanks are fitted with heavy copper circulating pipes through which cooling water is forced by means of a centrifugal pump operated by the shaft of the electric motor. The controller is operated by means of a hand wheel on the end of a long steel rod on the operating platform and connected with the oil-filled, high-tension reversing switch. The handle of this switch is interlocked with the main wheel, so that until the wheel is in the "off position" the connections cannot be reversed. There are water-filled resistance tanks also provided to supplement the oil-cooled metallic resistances above mentioned. Each of these water tanks holds 190 gallons and is constructed of 1½-inch elm plank. In starting the electric motor, these

The Loftus Ironstone Mines, Yorkshire, England.

water-filled resistance tanks absorb a large proportion of the energy, giving a very gradual acceleration to the haulage gear when a set of cars are picked up. These liquid tanks are coupled to the first three stops only of the controller and are then relieved of further work, the additional regulation being carried out by the water-cooled metallic resistances alone, beyond this point.

It is of interest to note that for the purposes of allowing the slack to be taken up gently between cars and for adjusting the length of the rope, a steady speed of from one to two miles per hour can be maintained by the haulage gear with the water tanks in circuit. There is a water receiver provided for the cooling of the metallic controller connected with the electric driven centrifugal pump by steel pipes 3 inches in diameter. This electric haulage installation is used to bring trips of from 30 to 50 tons at a time over the somewhat uneven road from Loftus or Grinkle. In the latter run there is a length of travel of 2,500 yards taking 10½ minutes from start to finish, with an average speed of 8¼ miles per hour.

In passing from No. 5 electric haulage room along the rope plane will be noted the junction of the Whitecliffe plane and Grinkle plane where is installed the 300 horse-power electric haulage gear of the direct connected type in the new No. 4 haulage room. The electric motor equipment water tanks and resistances as well as the controller and the main switchboard are the same in this installation as in No. 5 haulage room above described, but the haulage gear is of special interest owing to its massive design and great power.

There are two drums on the barrel, each 2 feet 8 inches wide and 6 feet diameter with a shield board 8½ feet in diameter over all. This electric gear of high power operates the Whitecliffe mine district where a large body of ore remains to be handled. The equipment operates at the comparatively high speed of 9 miles per hour, requiring a speed of 40 revolutions per minute on the drum shaft. A special friction clutch of the Hall type is provided on each of the two drums, consisting of a heavy cast iron center, keyed to the main shaft and revolving with it. There is an all-round brake strap 6 inches wide outside this center, provided with elm blocks and operated by means of rods and levers inside the haulage drum and connected to a sliding sleeve between the drums. The position of this sleeve is regulated by means of a handwheel with double threaded screw, and is so arranged that either drum may be stopped or put in motion as desired, the wear on the strap blocks being taken up by screws at the end of the straps.

The haulage gear is connected to the rotor shaft of the electric motor which operates at a speed of 325 revolutions per minute. This motor is capable of developing 450 horse-power at a maximum and is supplied with a two-phase current of 2,750 volts pressure. The motor has a wound rotor with massive slip rings outside of the end bearing, protected by a sheet iron cover. There is a cast iron box underneath the motor containing liquid resistances for absorbing the shock when switching out; this accessory being found of great advantage owing to the very frequent starting and stopping of the motor.

# Animal Experimentation—Its Benefits to Mankind—II*

By W. B. Cannon, M. D., George Higginson Professor of Physiology in Harvard University, Boston

Continued from SUPPLEMENT No. 1906, page 23

THE DISCOVERY OF USEFUL DRUGS.

Mankind has benefited from animals, not only in learning the bacterial transmission of various diseases and in the improvement of surgical technic, but also in the discovery of useful drugs. Indeed the whole modern science of drug-action is founded on animal experimentation. Consider for a moment what blessings have come from such investigations. All the drugs producing sleep which have been discovered during the past forty years have been discovered by experiments on animals. All the local anesthetics, as cocain, for example, rendering small surgical operations painless, have been discovered by experiments on animals. The only drug which will give prompt relief from the distress of angina pectoris is amyl nitrite—a drug which was discovered during experimentation on animals. All modern drugs for reducing fever; the cardiac tonic, strophanthus; the diuretics, caffein and theobromin; the emetic, apomorphin—were all introduced through experiments on animals. These do not by any means exhaust the list of medicaments discovered by the experimental method applied in pharmacology. Nor do they indicate all the uses of the method in that new science. Through tests on animals, some drugs whose worth was known have had their action more precisely defined; digitalis, for instance, is one of these. Others have been proved harmful; and still others have had their activity standardized. One of the most interesting examples of the use of animals to test the efficacy of drugs is that of ergot—a drug employed to stop hemorrhage, particularly the dangerous hemorrhage that sometimes follows childbirth. Ergot can thus be tested on an animal and proved potent before being placed in the hands of a physician, or it can be tested for the first time on a woman who is bleeding to death—the choice has to be made.

THE USE OF ANIMALS FOR DIAGNOSIS.

Prominent among the services of animal experimentation is that of helping in the diagnosis of disease. The *early* diagnosis of infectious disease is essential both for the treatment of individuals and for the prevention of epidemics. We depend on animal tests for determining many of the most serious, socially dangerous afflictions. In tuberculosis, for example, hope lies in early recognition of the nature of the illness. In the first stages the few tubercle bacilli in the sputum may not be observed under the microscope, yet the same material injected into a guinea-pig will clearly demonstrate their presence.

Cultures of the typhoid bacillus, injected into animals, will induce in the blood of the injected animals, power to cause typhoid bacilli, and typhoid bacilli alone, to gather in clumps. Thus the blood of the injected animals can be used to detect the presence of typhoid bacilli in suspected persons as, for example, the apparently normal bacillus-carriers, who are such a menace to public health.

Cholera-carriers, and persons afflicted with cholera in mild form, can be discovered by the same method. Indeed the protection of a country from invasion by cholera involves measures in which diagnosis by animal tests is a very important procedure. When we consider that in a single epidemic many thousands have died, and that wide-spread disturbances of commerce and industry have resulted, we can understand the essential value of finding and controlling the first cases.

In the diagnosis of plague, and to a more or less degree in the diagnosis of dysentery, Malta fever, anthrax, glanders, actinomycosis and other micro-parasitic disease, animal tests play an essential rôle.[11]

More and more we are depending on prevention rather than cure to reduce mortality. Without the means of early and correct recognition of the infectious diseases which animal tests have largely provided, the sanitarians, who stand as sentinels in our great cities and along our coasts, would be deprived of their weapons of defense and be rendered useless as protectors of the public health.

PHYSIOLOGY.

The first of the medical sciences to use experimental methods was physiology—the science of the normal working of organs. The abnormal working of organs in disease is necessarily measured by the normal standard which physiologic investigation has revealed. Take away from physiologic knowledge that which is based on animal experimentation and almost nothing would be left! Probably no system in the body more frequently requires earnest study by the physician than the circulatory system. As Erlanger has shown, with much thoroughness, practically all that we know of the course of events in the heart, the proper interpretation of the cardiac sounds, the factors determining blood-pressure, the nervous control of heart and arteries, the intelligent treatment of cardio-vascular disease—all have resulted from studies of animals.[12] What is true of the circulation is true also of digestion. Through the activities of a succession of investigators who experimented on animals, we now know the changes which food undergoes in each portion of the alimentary canal, the nature of the digestive juices, the condition under which they are poured out and, to a large degree, the causes and character of digestive disorders. Similarly we are now securing, through the brilliant researches of Sherrington and others, illuminating insight into some of the intricacies of the nervous system. These and many other notable contributions to physiology which almost daily stir our wonder at the marvelous organization of the body are the direct outcome of experiments on animals. It cannot be too strongly emphasized that almost the entire structure of psysiologic knowledge on which the modern physician bases his judgment—knowledge which to the practitioner makes all the difference between understanding and blind bewilderment—has grown from the application of the experimental method.

CRETINISM.

Physiology in co-operation with clinical medicine has also contributed directly to the cure of human diseases. The distressing malady known as cretinism is due to absence of the thyroid gland from birth. Formerly cretins spent their lives as imbeciles, stunted in stature and hideous in appearance. The semibestial aspect, blubber-lips, turned-up nose sunken at the root, wide-open mouth, lolling tongue, small eyes with swollen lids half closed, the stolid expression of the face, the muddy, dry skin—all combined to make a monstrous creature. The physiologic experiments of Schiff showed that implantation of the thyroid gland in the body would prevent the changes caused by extirpation. Then it was discovered that feeding the gland or injecting the gland-extract was as good as implantation. And now absence of the thyroid can be compensated for by administering by mouth either thyroids, or tablets which contain the essential substance, derived from lower animals. The transformation that occurs in the cretinous idiots, when treated early, is nothing short of miraculous. As Osler has said:

"Not the magic wand of Prospero, or the brave kiss of the daughter of Hippocrates, ever effected such a change as that which we are now enabled to make in these unfortunate victims, doomed hitherto to live in hopeless imbecility, unspeakable afflictions to their parents and to their relatives."

ANIMAL DISEASES.

I have now presented evidence which proves that our knowledge of the disastrous infections and our consequent ability to control them, both in individuals and in communities, have been derived directly from repeated, carefully-planned experiments. The immense saving of life which has resulted is not confined to human beings, however, but is shared by the lower animals as well. I need only mention tuberculosis, anthrax, glanders, hog-cholera, Texas fever and rabies, to indicate diseases which have in the past caused the destruction of domestic herds in enormous numbers, with vast economic losses. Happily the measures taken to protect the lowet animals against infection can be more rigorously enforced than those used to save human life, and the results therefore are all the more striking. By means of preventive measures and by protective inoculations, some diseases of cattle have been entirely abolished in this country, and others have been so promptly and radically dealt with that they have seldom made serious headway.[13]

PREVENTIVE MEDICINE.

That there is the same possibility of protecting human beings against diphtheria and rabies, against malaria and yellow fever, and against many other infections has long been known.

The oldest of the protective measures is that of vaccination against small-pox. This ravaging pestilence has been reduced, in a most striking manner, in every civilized country in which vaccination has been employed. Furthermore, the reduction of the disease and mortality has corresponded directly to the thoroughness with which the populations have been vaccinated and revaccinated. Germany, for example, has had no epidemic of small-pox since the compulsory vaccination law went into effect thirty-eight years ago, whereas in Persia and Asiatic Russia, where vaccination is neglected, small-pox is still a death-dealing scourge.[14] The claim that the disappearance of the disease is due to a general betterment of sanitation is not supported by our recent experience in the Philippine Islands. The six provinces near Manila, with a population of about one million people, had a record of over 6,000 deaths from small-pox annually before 1907. In 1907, vaccination was completed in these provinces. Since that year, in the six provinces, not one person who had been successfully vaccinated has died of small-pox

* Reproduced from the *Journal* of the American Medical Association.

[11] Rosenau: The Rôle of Animal Experimentation in the Diagnosis of Disease, Defense of Research Pamphlet III, 1909. Also Richardson: Animal Experimentation in the Development of Our Knowledge of Dysentery, Cholera and Typhoid Fever, Defense of Research Pamphlet VIII, 1910.

[12] Erlanger: Animal Experimentation in Relation to Practical Knowledge of the Circulation, Defense of Research Pamphlet XIII, 1910.

[13] Moore: Animal Experimentation; The Protection It Affords to Animals Themselves and Its Value to the Live-stock Industry of the Country, Defense of Research Pamphlet VI, 1909.

[14] Schamberg: Vaccination and Its Relation to Animal Experimentation, Defense of Research Pamphlet I, 1911.

and only a few cases have occurred among all classes.[15] Inasmuch as animals are used in securing the virus, these triumphs of preventive measures against the disease must be attributed to operations on animals.

Through the application of antirabic virus, death from hydrophobia—a hideous death—has fallen from between 6 and 14 per cent of persons bitten by rabid animals to a fraction of 1 per cent; more than 400 persons were bitten by mad dogs and treated by the virus in Paris in 1910, and there was not a single death. Any one who has read the life of Pasteur knows the dramatic story of his experiments on rabbits and his thrilling success in the very first human patients whom he treated. The conquest of rabies must be regarded as one of the greatest services rendered by animals to their fellow-beings.[16]

Another victory in the campaign to reduce illness and mortality has been won in the fight against mosquito-borne infections. Yellow fever and malignant malaria contributed more than any other one cause to the failure of the French to build the Panama Canal. The present remarkable freedom from these diseases at the canal, which is permitting the triumphal completion of that stupendous work, is highest testimony to the efficacy of preventive medicine when well-known methods of control can be thoroughly enforced.[17]

Of the volunteer regiments mobilized during the Spanish-American war, 90 per cent became infected with typhoid within the first eight weeks after mobilization. In the entire army nearly 21,000 men were disabled by this disease and more than 1,600 died of it. Last year 12,800 men of the American army were mobilized at San Antonio, Tex., for several months. Only *one* case of typhoid fever, that of a hospital attendant not yet immunized, appeared in the entire force. That this extraordinary phenomenon was due to protective inoculation against typhoid infection, which each soldier received before going into encampment, is indicated by the prevalence of typhoid in San Antonio during the period. The experience of the British army in India has been similar.

The entire modern process of protective inoculation is a direct outgrowth of artificial immunity previously demonstrated in animals (Richardson). And the sole hope of rendering wide areas of tropical country fit for civilized society rests on the possibility of eradicating native diseases through the well-tested and efficacious methods of preventive medicine.

### ANTIVIVISECTIONISTS AND THEIR METHODS.

Such, then, are some of the benefits to man and to lower animals of the experimental method applied to medical problems. In spite of these benefits, however, strong hostility to this method of studying disease is felt by certain persons who call themselves "antivivisectionists." These persons have no direct acquaintance with the conditions of experimentation; many of them scorn the evidence that any advantage to man has come from studies on animals; to support their contentions they send broadcast phmphlets in which are printed hostile opinions of medical men who are long since dead, men who had no conception of the merciful procedures of modern experimentation and its life-giving results; or they quote the testimony of spurious experts whose reputations were made in literature, art or theology, and not in the service of healing. However well-meaning their motives may be, their literature for years has been characterized by fraud and trickery and evil insinuation which have been repeatedly pointed out, but with no effect.[18] These methods of American antivivisectionists duplicate those of the English. The Royal Commission, which has just reported after five years of study and consideration, has declared of the antivivisectionists, their "harrowing descriptions and illustrations of operations inflicted on animals, which are freely circulated by post, advertisement or otherwise, are in many cases calculated to mislead the public." Both in this country and abroad, therefore, the active antivivisectionists have sought, through garbled statements, false evidence and inaccurate description, to cast such discredit on medical research as to give the impression that pain and premature death cannot be escaped through application of the experimental method.

### THE ETHICAL QUESTION.

Even when these reactionaries grant somewhat grudgingly that the distress of living creatures has been diminished by animal experimentation, they contend that the method of securing this result was immoral and is therefore unjustifiable. What renders the experimental use of animals immoral is difficult to understand when we consider other uses to which they are put. We force the harnessed horse to work, and in time of crisis, we drive him with lash and spur. We rob the mother cow of her calf, and then appropriate her milk. We permit the dehorning of cattle and their branding with hot irons. We do not object to the most shocking barn-yard operations, performed (without the sniff of an anesthetic) merely to make more palatable the flesh we eat. We slaughter ruthlessly, for sport, myriads of birds and beasts. Myriads more we slaughter for their furs and feathers. We kill for food every year in this country more than 50,000,000 beeves, sheep and hogs, and also 250,000,000 chickens, turkeys, ducks and geese. In nineteen of the largest cities in the United States more than 350,000 dogs and cats are destroyed annually, merely to clear the streets. Vermin and wild animals we subject to death in uncertain traps or end their existence with distressing poisons. If all injury and destruction of animal life is immoral, why select as an object for attack the treatment of the relatively few animals employed in the laboratories with the object of reducing pain and suffering in the world?

Surely the life of lower animals is not so sacred that we cannot utilize it for our own betterment. Society protects itself from harm by holding in quarantine dangerous human beings, or by incarcerating them, or even by killing them. If attacked by a foreign foe, society does not hesitate to send into battle its young men, chosen for their strength, to suffer grievous wounds and death for the social welfare. Such necessary sacrifices of our fellow men are among the tragedies of social existence. The sacrifices of animals, in various ways so essential to the continuance of the human race, may be regarded as among the tragedies of their existence. But of all these, what sacrifices could be more thoroughly justified morally than those of experimentation, which have contributed so greatly to the reduction of suffering and to prolongation of life, both for men and the animals themselves?[19]

### PRECAUTIONS AGAINST PAIN.

I do not wish to give the impression that any one engaged in animal experimentation would, under any circumstances, justify the infliction of needless pain. That animals are in fact used humanely for the purposes of medical research has been again and again maintained and demonstrated whenever the question has been carefully examined. The English laboratory inspectors and the English Royal Commission are unanimous in testifying to the absence of cruelty in experimental procedures. In this country practically all institutions in which animals are used for medical and biologic research have adopted, by public and corporate action, regulations which place control of experimentation with the laboratory director. These regulations provide for the bodily comfort and the sanitary surroundings of the animals, and require all operations to be sanctioned by the director, who is held responsible for the importance of the problems studied and the propriety of the laboratory procedures. Furthermore, the regulations require all operations likely to cause greater discomfort than anesthetization itself to be done under anesthesia, and to be followed by painless death. Only the director can make exceptions to these last provisions, and he can do so only in the rare cases in which anesthesia or death of the animal would defeat the object of the experiments.[20]

The laboratory director, of all men, is most likely to know what is being done by those about him; more than any one else he is responsible to his institution, to the public interests and to his professional ideal; and his position is a warrant of his trustworthiness. To the laboratory director, therefore, the medical profession looks for the exercise of that enlightened compassion which lies at the heart of all medical service.

### OBJECTIONS TO PROPOSED LEGISLATION.

In spite of accumulated evidence that animal experimentation is conducted in a humane manner in this country, and that strict precautions have been taken against infliction of unnecessary pain, every year in one State or another a "mild" restrictive bill is alluringly presented by the antivivisectionists. Its ostensible purpose is, not to prevent "legitimate vivisection" by responsible investigators, but to stop the practice among the unskilled—for example, the medical student in his room. Examination of the bill reveals, however, that no provision is made for spying on the medical student in his room, but that every arrangement is made for inspection of the responsible investigators. To many persons inspection seems reasonable; they approve of going at least so far with the petitioners for legislation. The medical profession, however, has in the main offered objections to the proposed inspection.[21]

These objections are based to some extent on the attitude of the antivivisectionists toward inspection as it has been carried on in England during the past thirty-six years. During all this period no noteworthy abuse of animal experimentation has been revealed by the inspectors. The inference drawn by the antivivisectionists is that occasional inspection is futile; indeed, they declare that, unless an inspector is in the laboratories continuously during all operations, horrible abuse of animals is sure to occur.[22] The impossibility of providing for such constant oversight would suggest to a person of common sense that a reasonable reliance be placed on the good will and natural humanity of those engaged in research. The agitators in this country, however, have argued that when danger of wrong exists, as in the conduct of a bank, for example, inspection is provided, and therefore laboratory inspection should be provided. An important defect in this argument rests in its application. For the inspection of banks experts in banking are appointed, but for the inspection of laboratories experts in experimentation are definitely excluded in the proposed legislation. For this important work the antivivisectionists desire only their own representatives. In the opinion of the experimenters such persons, untrained in observing and judging animal reactions, and lacking any insight whatever into the extraordinary complexities of medical investigation, are thoroughly incompetent. Indeed the most charitable interpretation to be placed on the ridiculously false and misleading statements continually made by these persons is that they are profoundly ignorant of processes which the laboratory workers have spent many years in learning—the most involved and entangled processes in nature, those occurring in highly organized animals.

Apart from objecting to inspection because it has not satisfied the antivivisectionists themselves, because it has not revealed abuses and because incompetent inspectors are insisted on, we may reasonably regard it as merely the first step in an effort to stop experimental medicine absolutely. In Great Britain, where legal restriction has gone farthest, there are no less than fifteen antivivisection societies urging that experiments on animals be abolished. In this country there are at least six such organizations whose aim likewise, expressed or implied, is abolition. The agitation for "mild" bills, for inspection or for slight restriction by these groups of agitators is, under the circumstances, properly regarded as merely the initial move toward total suppression of what has been demonstrated in these last sixty years as the most powerful instrument of medical progress that has been devised.

### THE TWO PARTIES.

The issue then is joined. On the one side are the antivivisectionists who insist that animals shall not be experimented on, even though mankind may thereby be saved throughout coming centuries from pain and premature death. On the other side are the investigators, successors of those who first applied to medical problems the experimental method, a method which, besides delivering into our hands the unlimited energies of the physical world, has in a few decades wrought marvelous advances in our ability to conserve human life. These men realize that numerous sources of distress are still unexplained. Measles, scarlet fever, infantile paralysis, fatal diseases of the kidneys and liver, cerebral degenerations, the awful scourge of cancer[23]—almost all progress in our knowledge of these afflictions has come from experiments on animals—but how much more remains to be accomplished! Men and women and children, whose suffering extends to every one bound to them by the strong ties of love and sympathy, daily go down to death because the disease is a mystery and its cure unknown. Who shall say that experimental medicine shall not continue to bring its blessings? In the eager search for more light, who shall decide the critical case involving pain to animals? The antivivisectionists maintain that they should decide; the physicians, on the contrary, urge that the decision remain in their control. The antivivisectionists, ignorant of the problems and methods of medical research, limit their humanity to the welfare of the laboratory animals. The physicians, perceiving that more power to fight disease can only come from more knowledge, trust the deeper humanity of the investigators who are seeking that knowledge. In the end society, which reaps the benefit of medical progress, must determine which of these contending parties shall prevail.

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[15] Heiser: Public Health Reports, 1911, p. 277.

[16] Frothingham: The History, Prevalence and Prevention of Rabies and its Relation to Animal Experimentation, Defense of Research Pamphlet VII, 1910.

[17] Marshall: Animal Experimentation in Relation to Protozoan Tropical Diseases, Defense of Research Pamphlet XI, 1910.

[18] Cannon: Characteristics of Antivivisection Literature, Defense of Research Pamphlet XIX, 1911.

[19] For further discussion, see Angell: The Ethics of Animal Experimentation, Defense of Research Pamphlet V, 1909.

[20] Cannon: Medical Control of Vivisection, Defense of Research Pamphlet XVI, 1910.

[21] It is, perhaps, unnecessary at this point to indicate the absurdity of the cry for the "open door." No one of insight and judgment is excluded from laboratories of medical research. In fact, in every laboratory with which I am acquainted the doors are freely open to biologists and persons with medical training. To be sure, not everybody is welcomed, but not everybody is welcomed to a hospital operation. The surgeon, operating in a home does not permit the "open door;" he even goes so far as to exclude close relatives of the patient. Yet he does not become thereby the object of malignant suspicion.

[22] Minutes of Evidence, English Parliamentary Commission on Vivisection, 1905-6, Coleridge's testimony, *passim*.

[23] Ewing: Animal Experimentation and Cancer, Defense of Research Pamphlet IV, 1909.

# Xylology, a New Branch of Science

## Identifying Different Woods and Detecting Fraudulent Substitution

XYLOLOGY is an entirely new branch of science that has just been developed by Uncle Sam's experts at Washington. It is a very important science, for it deals with the structural characteristics of wood, and the facts and principles upon which it is based are now finding expression in matters relating to forestry, agriculture, civil engineering, and particularly in all phases of the uses of the products of the forest. It is linked with the timely subject of conservation which has been brought so forcibly to public attention within the last two or three years that hardly a newspaper or a magazine can be taken up without coming in contact with some of its principles.

It may be asked what xylology has in common with the conservation of natural resources. Yet to those in charge of identifying native and foreign woods it is clear that the relation is not only a close one, but that xylology is a natural outgrowth of the destruction of the products of our forests.

The chief cabinet and construction timbers formerly employed are now becoming scarce, or, in a few cases, practically exhausted. Black walnut, yellow poplar, red gum, black cherry, white pine, and hemlock have been extensively exploited, and suitable substitutes are now being sought. There are those who are inclined to dispute that these excellent timbers are growing scarce, but the fact remains that the best and most accessible trees of these species have been cut and the present prices for the best grade are almost prohibitive.

Xylologists at Work in the Laboratory.

Certain other woods are now being used in place of them. Instead of black cherry, birches are being used, which are also becoming scarce. Black walnut was formerly so highly esteemed that it was used in the form of veneer to cover Spanish cedar, which is now classed with the best cabinet timbers. Western white and sugar pines are sent to the eastern markets to supply the demand for our eastern white pine. Hemlock, which was formerly cut simply for the sake of its bark for making tannin extract, is so scarce that the tannin we use now must be obtained chiefly from other sources.

As a result, there are now being imported annually into the United States millions of tons of forest products to take the place of our gradually decreasing supply. This imported material often requires the closest kind of inspection in order to avoid fraudulent substitution. This is particularly the case with woods from which dye or tannin is obtained, and with ground wood and bark of trees having medicinal value, all of which must be carefully examined and identified.

True mahogany in the West Indies and Central America is growing scarcer every year, and wood users are very eager to secure a suitable substitute. During the last two decades no less than 25 different kinds of woods have reached London, Liverpool, and New York and there sold as mahogany. In many instances the purchaser of these woods is under the impression that he is getting the only true mahogany, when in reality he is often paying the price of mahogany for a much inferior wood. Superficial appearances often deceive; the trusty microscope never. There has sprung up a distinct need for men who can tell these woods apart, a work that is a direct result of the destruction of the forests.

The chief purpose of this work is not simply to detect fraudulent substitutes and to establish scientific testimony for prosecuting those knowingly substituting inferior woods. It has a greater object in view, namely, ferreting out new and little known woods with properties and structural characters similar or nearly similar to those well known kinds which are now being rapidly exhausted. Superficial and gross characteristics cannot always be relied upon in selecting a substitute for a certain wood with special qualification, nor are tests relative to their physical properties always conclusive as to whether one kind may be substituted for another of well known characteristics. The xylologist is usually best able to tell the uses to which a wood may be put, the same as an assayer can determine the value of an ore.

This new work has been developed to cast new light upon weighty problems in the uses of the product of the forest. It is unique, and although decidedly new, it has already proved its value. The study promotes general interest in the investigation of gross and minute characters in wood that add to or detract from its usefulness for certain purposes. Xylology gives emphasis to the study of the elements of the wood, as well as to their manner of grouping or arrangement and the proportion in which they are present. The prevailing structural characters of the elements in wood are very carefully studied and recorded as an aid chiefly for identification.

The object in view—the identification of woods for timber merchants, lumbermen, wood users and laymen—is decidedly different from anything that is being done in any other laboratory in this country. The results of this work can best be shown by the numerous letters of appreciation frequently received from men who have been assisted.

During the last decade the scientific method of studying woods has grown slowly, but with increasing accuracy and success. To make known the results of this novel phase of so-called applied wood anatomy, publications are gradually being issued and so popularized that the layman will be able to understand and appreciate them. The woods of the United States are now being studied group after group, and publications issued on each group as fast as the data can be compiled and arranged. As the results of this study increase both in quantity and popularity, other investigators will undertake the work of discovering other facts and developing new methods of classification, so that in a comparatively short time we may expect a new literature which may be appropriately called "xylological literature."

A quarter of a century ago xylology was only studied by a few. These investigators, however, dared not devote a great deal of time to ascertain whether or not the characters in wood of different species actually yielded distinctive differences, so that one could tell for instance the wood of butternut from that of black walnut. Theodor Hartig, who, in 1878, published his important work "Ueber den Bau des Holzes der in Deutschland Wildwachsenden und Häufiger Cultivirten Bäume und Sträuche," asserted that he did not see that the method of distinguishing the different woods by their structural characters could be made practicable. Later in his career, however, he predicted that the time was near at hand when a way would be found to make the results of such research of some practical assistance to wood users. This prediction of Hartig's has become true. The way has been found—combining the rule-of-thumb method formerly employed in distinguishing woods with the scientific method, and in this manner giving the public practical instruction.

The aim and ultimate results of these xylological investigations are most vital, not only to those who are concerned with the study and teaching of plant anatomy, but also to all users of wood. Original research work along this line is not a field for the untrained, but a life study for men with ability and ambition. Though it is in its infancy and has accordingly made many mistakes, its importance is surely and steadily gaining the attention of lumber dealers and men at the head of wood-using industries. Necessity for such work is being felt wherever lumber is now being bought or sold, and the range of its usefulness is growing remarkably.

The determination of the correct names of woods will exercise an influence upon importers of foreign woods cautioning them not to palm off upon the public a wood not true to name. The future of the work looks bright indeed. In fact the present indications are that the time is just dawning when increased demands will be made upon trained men who know and can tell the chief commercial woods apart at a glance and who know what means to employ to find out in case the wood is new and unfamiliar.

The men who have made good in the mining business are those who know best the value of ore at a glance. The same holds good in the timber business. A keen knowledge of woods, their structural characteristics, and the possible uses to which they can be put, is what one has got to possess if he wishes to become expert in the identification of woods.

Those who have studied the scientific method of identifying woods have secured certain definite results that indicate, in a most interesting manner, the future possibilities of the method. The literature, though at present small, is being read by many, and those interested are constantly growing in number. The one thing that prevents more students from taking up this work is that it requires a many-sided training. The investigators must possess a knowledge of the sequence of orders and families of plants.

Those who have faithfully applied the scientific method in the investigation of woods have made far better progress than those who relied wholly upon the rule-of-thumb method. The former is the product of man's effort to apply a method that contains the possibilities of every improvement or advancement gained through the means of the compound microscope. The minute characters combined with the gross characters employed in the rule-of-thumb method render the identification quite practicable. After one has determined the minute characters, they will stand out distinctly before the mind, and the next step is to examine all characters with a view of finding which ones are sufficiently constant to be of real use in their practical application. This requires considerable research, but when once these characters are found the investigator has something substantial to go by. The next step is to ascertain by comparison with similar characters previously observed in other woods whether they are of real practical assistance for purposes of classification. It is true that the scientific method can be made practical for such woods as have distinctive characters, and it is generally conceded that all woods of valid species have characters of practical value, though they may sometimes be hidden from the view of the casual observer.

This leads us to the very important conclusion that the scientific method may possibly be so developed that it will serve to obtain identification of woods without the aid of the rule-of-thumb method.

Scientific methods are invading every field of industry and commerce, and although unfortunately a great deal of prejudice still exists in various quarters against what to the uneducated layman may sometimes appear useless academic refinements, fortunately the modern spirit is gaining headway everywhere and material rewards are never lacking.

# The Conductivity of Dielectrics

## Its Variation with Frequency and Other Factors

By Dr. J. A. Fleming, F. R. S.

It is well known that dielectrics such as gutta percha, India rubber, paper, glass, celluloid, and mica conduct electricity to a small extent. In other words there is no such thing as a perfect insulator. This conductivity, however, is of a different character from that of metals.

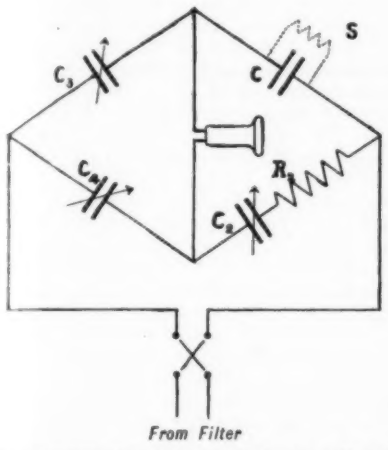



Fig. 1.—Fleming and Dyke Variable Capacity Bridge.

It does not obey Ohm's law. Moreover, there is considerable difficulty in separating out the true conduction current from the slow increase in the electric displacement, commonly called the capacity current, which latter involves conservation of energy and not dissipation like a true conduction current. When we subject dielectrics to alternating currents it is well known that there is an additional dissipation of energy which has sometime been ascribed to "dielectric hysteresis," a rather vague term and by no means very exactly defined. Again telephonists are well aware that in the case of gutta percha the true conductivity for alternating currents is markedly greater than the conductivity for direct currents.

It was the desire to explore these dielectric phenomena more completely which led the writer in conjunction with his assistant, Mr. Doyle, to undertake a long series of investigations on dielectrics, the results of which were lately put before the Institution of Electrical Engineers. As the chief interest in connection with dielectric energy absorption lies in connection with the losses in cable insulation when conveying alternating currents and since the question of energy losses at low frequency and high voltage has already been fully considered by B. Monasch and E. H. Rayner, I was resolved to limit the present inquiry to low voltage and high frequencies lying between 800 and 5,000, as this has a particular interest in connection with telephony. The first question was the provision of the necessary high frequency electromotive forces which must necessarily be of simple sine form to enable a valid and simple theory of measurement to be employed.

In the Pender Electrical Laboratory of University College, London, we possess a high frequency alternator of 3 K. V. size built for a frequency of 1,000.

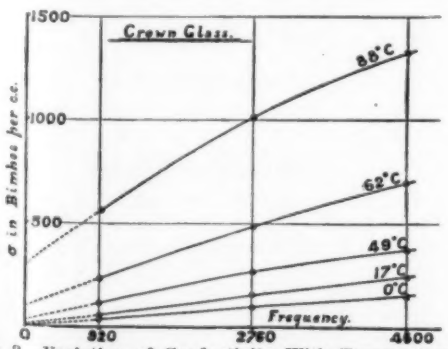
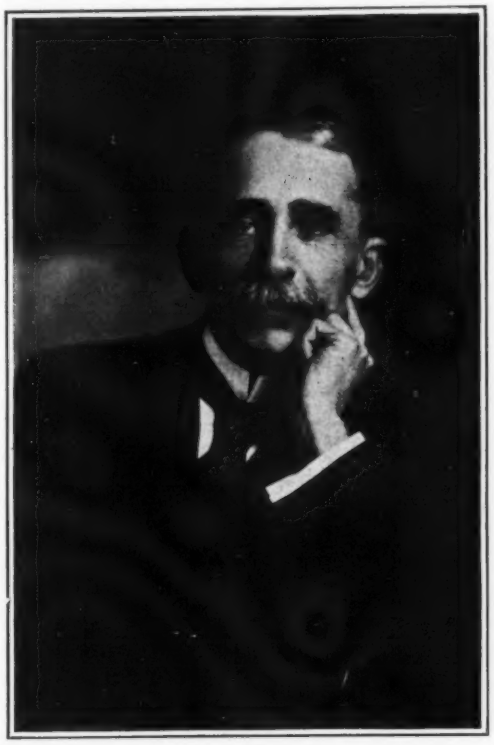



Fig. 3.—Variation of Conductivity With Temperature and Frequency for Glass Condenser.

The electromotive force curve as investigated by a Braun cathode ray oscillograph proved to be very far removed from a sine curve and to contain a pronounced third and fifth harmonic constituent.

This however proved to be an advantage by arranging in series a variable inductance coil and a condenser. A resonant circuit was constructed which could be tuned to resonate to the frequency of either the fundamental or the upper harmonics. By such an harmonic filter it is possible to pick out and separate electromotive forces having frequencies either of 920, 2,760 or 4,600, from the same alternator, thus making it equivalent to three machines in virtue of the irregular form of the natural electromotive force curve.



John Ambrose Fleming.

In fact we perform on our alternator, electrically speaking, the operations mathematically expressed by Fourier's theorem. We had then to consider the best method of measuring the losses in the dielectrics of cables and condensers. As we desired to employ small condensers and short lengths of cable which could be heated in an electric oven or cooled in refrigerants, we were not able to make use of a wattmeter method, static or dynamic, as this is applicable only when the power absorption is fairly large or the voltage high. After consideration of several methods we at last adopted a bridge method in which the four arms consist of four capacities, three being composed of variable capacity air condensers and the fourth of the condenser formed with the dielectric under test. In series with one of the variable air condensers is placed a variable inductionless resistance $R^2$ (see Fig. 1) and across the bridge is placed a telephone. The bridge is supplied with a simple sine curve E. M. F. of frequency 920, 2,760 or 4,600, obtained by selecting the fundamental or one of the higher harmonics from the E. M. F. of the alternator.

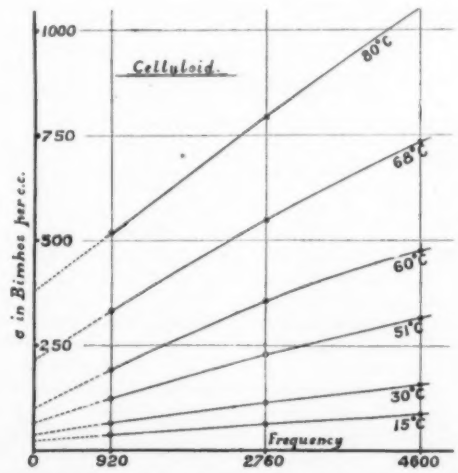



Fig. 4.—Variation of Conductivity With Temperature and Frequency for Celluloid Condenser With Tinfoil Electrodes.

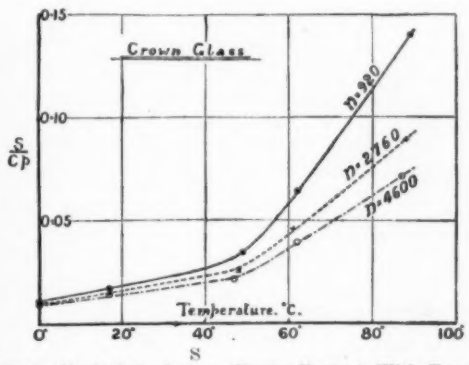



Fig. 2.—Variation of $\frac{S}{Cp}$ (Power Factor) With Temperature and Frequency for Glass Condenser.

The condenser under test must be regarded as a pure capacity $C$ or parallel with a pure conductivity $S$, and as is well known this can be balanced on an alternating current bridge against a capacity $C_2$ in series with a resistance $R_2$. If the balancing capacity $C_4$ and $C_3$ and the resistance $R_2$ are suitably adjusted we can find values such that there is no sound in the telephone. When this is the case it is easily proved that the following relations between the quantities hold good,

$$\frac{S}{2\pi^n C} = 2\pi^n C_3 R_3, \qquad \frac{E_3}{C_4} = \frac{C}{C_2} + R_2 S$$

where $n$ is the frequency of the current. The ratio $S/2\pi^n C$ or $S/Cp$ is very nearly the power-factor of their dielectric, and from the above equations we can determine also the separate values of $C$ and $S$ or the capacity and conductance of the condenser.

From the dimensions of the dielectric we can calculate the specific conductivity and dielectric constant from the values of $C$ and $S$. The conductivity is best measured in *bimhos* or billionths of a mho, the mho being the conductivity of an ohm and a bimho that of a million megohms. These measurements were taken for various dielectrics over a wide range of temperature, and the results are graphically depicted in the following charts. It appears that the power-factor $S/Cp$ for a dielectric is a function of the temperature in many cases having a maximum value for a certain temperature. Also the conductivity $\sigma$ is a function of the frequency and in a large number of cases can be represented by a straight-line law, $\sigma = a + bn$. In other words the conductivity of a dielectric is made up of two parts, the part $a$ which is independent of frequency and is probably identical with the direct-current conductivity, and a part $bn$ which is proportional to the frequency. Hence the true conductivity of a dielectric for alternating currents is often very much greater than for direct currents.

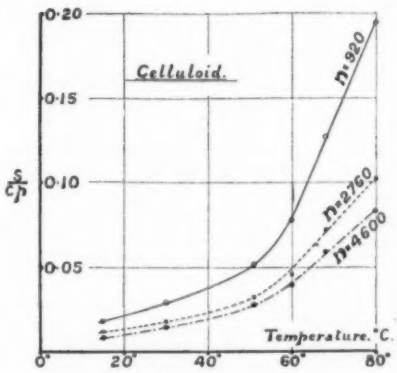



Fig. 5.—Variation of $\frac{S}{Cp}$ With Temperature and Frequency for Celluloid Condenser With Tinfoil Electrodes.

It was found that the presence of moisture in the dielectric always greatly increases that part of the con-

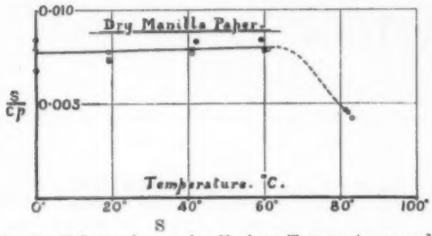



Fig. 6.—Values of $\frac{S}{C\,p}$ for Various Temperatures and Frequencies for Manilla Paper Condenser.

Note.—Observations at 920 p.p.s. represented by black dots; ditto at 2,760 by crosses and at 4,600 by small circles.

ductivity denoted by *a*. Also for dielectrics of good insulating power for direct currents the line representing the conductivity in terms of the frequency passes nearly through the origin. Taking then the dielectrics in order they are characterized as follows:

*Glass.*—At low temperatures the power factor is independent of the frequency (see Fig. 2). This implies that the *a*-conductivity is very small. The conductivity lines in terms of frequency are straight lines passing through the origin (see Fig. 3). Above 40 deg. Cent. the power factor increases rapidly with temperature but less rapidly the higher the frequency. This shows that above 40 degrees there is a sensible amount of *a*-conductivity which increases very rapidly with rise of temperature.

It is well known that glass is an electrolyte at high temperatures. Hence this suggests that the intercept of the conductivity lines on the vertical axis through the origin denotes this direct current on zero frequency conductivity. It is probable therefore that this part of the conductivity denoted by *a* is electrolytic in nature.

*Celluloid.*—The same facts are noticed in connection

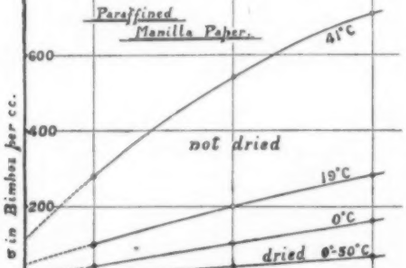



Fig. 9.—Variation of Conductivity With Temperature and Frequency for Paraffined Manilla Paper, Dried and Undried.

with celluloid (see Figs. 4 and 5). The power factor increases rapidly with the temperature but less rapidly the higher the frequency. Also the conductivity for alternating currents at various frequencies is represented by a series of nearly straight lines. The conductivity for currents of frequency *n* is denoted by $a+bn$.

Hence we see that the alternating-current conductivity is much larger than the direct-current conductivity and increases rapidly with the temperature.

*Paper.*—If paper is extremely well dried then the power factor is constant and independent of frequency and temperature. The alternating-current conductivity for various frequencies is represented by a straight line passing through the origin. In other words, the conductivity $\sigma = bn$ where *b* is a constant and *n* is the frequency (see Figs. 6 and 7). If, however, any moisture is present in the paper then the conductivity lines no longer pass through the origin but have an intercept on the vertical axis which is a measure of the direct-current conductivity (see Figs. 8 and 9). The slightest moist-

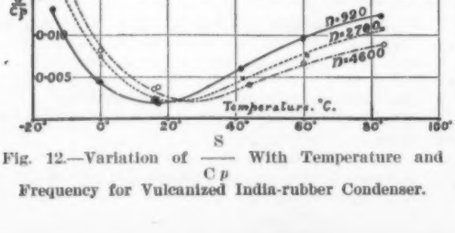



Fig. 12.—Variation of $\frac{S}{C\,p}$ With Temperature and Frequency for Vulcanized India-rubber Condenser.

ure in the paper immensely increases the dissipation of energy in it with alternating currents. Hence the moral is that in making paper condensers or paper insulated cables the paper must be perfectly desiccated and also kept dry. No impregnation with paraffin or resins is any use unless the paper is perfectly freed from moisture.

*Ebonite.*—Ebonite is remarkable because over the whole range of temperature employed the power factor is independent of frequency. This shows that the alternating conductivity is proportioned to the frequency. In the diagram showing the A. C. conductivity in terms of frequency (see Figs. 10 and 11) all the lines pass

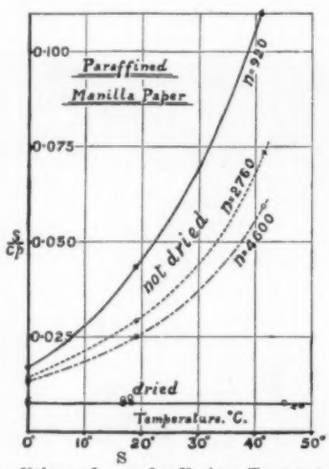



Fig. 8.—Values of $\frac{S}{C\,p}$ for Various Temperatures and Frequencies for Condensers Made With Paraffined Manilla Paper, Dried and Undried.

through the origin. Ebonite has therefore a very small or zero conductivity for direct currents but it has a very considerable conductivity for alternating currents. Its power factor and conductivity increase rapidly with rise of temperature.

*Vulcanized India Rubber.*—This dielectric has very peculiar properties. The power factor has a minimum value near 20 deg. Cent. and experiments made with powerful cooling agents have shown that the power factor then rises to a very large maximum value at about —20 deg. Cent. or — 30 deg. Cent. at which it is some 14 times greater than at + 20 deg. Cent. The conductivity lines in terms of frequency are not straight lines but yet if produced would all pass nearly through the origin (see Figs. 12 and 13), thus showing that vulcanized India rubber has a very small direct-current conductivity but a very considerable alternating-current conductivity.

*Gutta-percha.*—This dielectric also is abnormal. Its power factor has a maximum value near 10 deg. Cent.

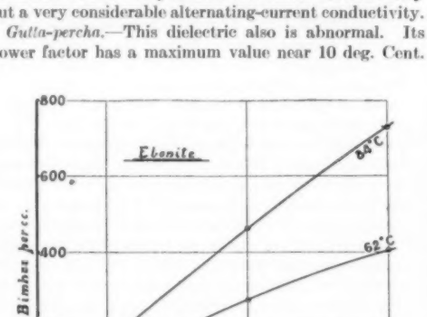



Fig. 11.—Variation of Conductivity With Temperature and Frequency for Ebonite.

and then decreases both with rise and fall in temperature. The conductivity lines are not straight lines but nevertheless all pass nearly through the origin (see Figs. 14 and 15).

This shows that gutta-percha is a very good insulator for direct currents but has a marked conductivity for alternating currents.

Additional experiments on such dielectrics as sulphur, paraffin, mica, slate, and other substances have shown that small direct conductivity is not necessarily associated with small alternating-current conductivity and that in the majority of cases the A. C. conductivity is a function of the frequency of the form $a+bn$. The importance of these facts in connection with telephony and telegraphy is obvious. It is quite erroneous to assume

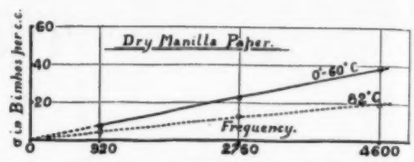



Fig. 7.—Variation of Conductivity With Temperature and Frequency for Manilla Paper.

that the dielectric leakance of a cable for telephonic currents is the same as the reciprocal of its insulation resistance measured as usual with direct currents.

This is particularly the case with gutta-percha, for this dielectric has a very considerable conductivity for telephonic currents. The ratio of dielectric conductivity to capacity per mile or $S/C$ for a telephonic cable is an important quantity as it helps to determine the speech-conveying power of the cable. It is an advantage for this ratio to be as small as possible. For ordinary gutta-percha this ratio is about 120, but by special treatment of the material Messrs. Siemens Bros. have succeeded in reducing it to 12 in manufacturing their latest telephone cables. Experiments at very low temperatures made by the writer with liquid air have shown that all good dielectrics have zero conductivity, in other words became perfect non-conductors at temperatures approaching the absolute zero. On the other hand, pure metals become perfect conductors or have no reistance.

In the paper describing these measurements made by the writer of this article in conjunction with Mr. Dyke, which was recently read to the Institution of Electrical Engineers in London and awarded the Institution premium, the following are the conclusions reached.

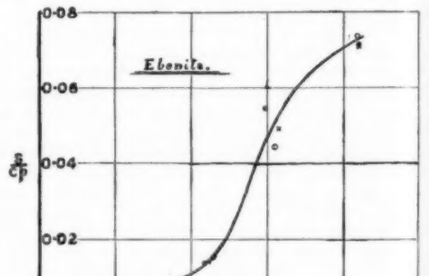



Fig. 10.—Variation of $\frac{S}{C\,p}$ With Temperature and Frequency for an Ebonite Condenser.

1. All the dielectrics so far tested prove to possess a true dielectric conductivity for alternating currents considerably greater than for steady unidirectional currents.

2. This increased conductivity implies greater power dissipation for the same terminal potential difference or voltage.

3. The alternating current conductivity increases with the temperature except in the case of vulcanized India rubber rather below 20 deg. Cent., and gutta-percha rather above 15 deg. Cent., in both of which cases it decreases with rise of temperature. In the case of mica and very dry paper it is not affected to any sensible extent by rise of temperature over a range between 0 deg. Cent. and 60 deg. Cent.

4. The alternating current conductivity is in most cases a linear function of the frequency and may be expressed in the form $\sigma = a+b\,n$, where *a* and *b* are coefficients, which are functions of the temperature, and *n* is the frequency.

5. The alternating-current conductivity, especially

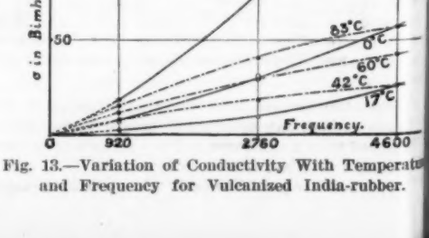



Fig. 13.—Variation of Conductivity With Temperature and Frequency for Vulcanized India-rubber.

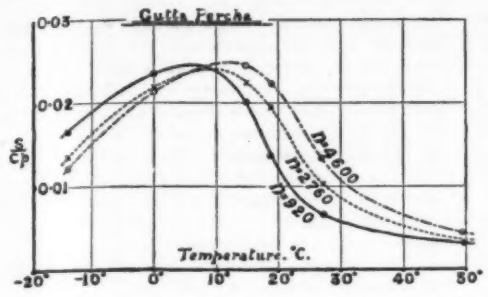



Fig. 14.—Variation of $\frac{S}{C\,p}$ (Power Factor) With Temperature and Frequency for Gutta-percha Condenser.

that part of it denoted by $a$, is greatly increased by the presence of moisture in the dielectric. This part is probably identical with the true direct-current conductivity.

6. The part of the conductivity denoted by the coefficient $a$ is possibly electrolytic in nature, while the part proportional to the frequency is a consequence of an energy loss which is possibly analogous to the hysteresis loss in iron.

7. The dielectric constant for alternating electric force is in most dielectrics rather smaller than that for steady or unidirectional electric force. In no case is it larger.

8. In the case of pure India rubber and vulcanized India rubber the temperature coefficient of the dielectric constant may perhaps be negative within the range of telephonic frequencies, and 0 deg. Cent. to 50 deg. Cent., but this result is not quite certain.

9. The ratio $S/C\,p$, nearly identical with the power factor, is, for some dielectrics such as mica and dry paper, a constant independent of frequency and temperature. For most dielectrics it increases with rise of temperature but decreases with rise of frequency. The power-factor variation with temperature of vulcanized India rubber and gutta percha is quite abnormal.

10. Those dielectrics such as celluloid and gutta percha, which have large alternating-current conductivity, although free as far as possible from moisture, also exhibit in a marked manner the phenomena of dielectric absorption and residual charge.

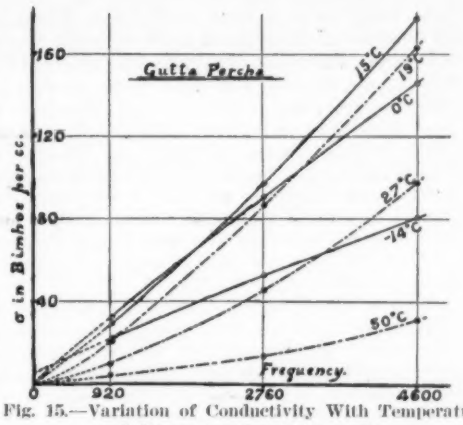



Fig. 15.—Variation of Conductivity With Temperature and Frequency for Gutta-percha.

11. For certain dielectrics there is a temperature at which the power factor and alternating conductivity have maximum values.

# The Elusive Will-o'-the Wisp

## One of Nature's Unsolved Enigmas

By Charles Fitzhugh Talman

WHAT has become of Will-o'-the-Wisp? As a handy metaphor Will is no less common than of yore. As a physical entity he appears, in this country at least, to have passed into the category of traditional things. The impression prevails that, if he was ever more than a myth, he is now no better than a memory, and that his unearthly light was finally extinguished about the time of our adolescence—which puts him in the same class with the long winters of unlimited sleighing. The reference-books tend to ignore him. You will seek him in vain in the new Encyclopædia Britannica.

Murray's Dictionary (under *ignis fatuus*) says: "It seems to have been formerly a common phenomenon, but is now exceedingly rare." However, this retrospective attitude toward will-o'-the-wisp is by no means confined to our own times. An essay on this meteor in the *Penny Magazine* for July 12th, 1845, begins with the following words: "Most persons are aware of the fact that the moving lights called Will-o'-the-Wisp, or Jack-o'-Lantern, were much more frequently seen and talked of in former years than they are at present." Apparently he was *always* "more frequently seen in former years than at present," for exactly the same reason that the winters of our childhood were longer and colder and more snowy than those of to-day. His presence created a lasting impression; his absence was the normal order of things.

The obsolescence of will-o'-the-wisp in English and American scientific literature makes it necessary for the student to turn to another language, viz., German, to find out just what is known to-day concerning one of the most curious phenomena of Nature. In Germany the "Irrlichterfrage" ("will-o'-the-wisp question") is still actively discussed; although there, as elsewhere, the opinion prevails that the phenomenon was formerly much more common than it is now.

The first scientific account of will-o'-the-wisp appears to have been that given by Musschenbroek, the Dutch physicist, in a work published in 1726. He entertained no doubts as to the reality of the phenomenon; described it about as it is commonly described to-day; but declared that specimens had been captured and found to be masses of slimy material resembling frog-spawn. He believed that they consisted of phosphorus.

In the early part of the nineteenth century the belief in the reality of will-o'-the-wisp was still unshaken; and it was explained—as it still is to-day in the encyclopedias that religiously enshrine the fossilized opinions of our grandfathers—as due to the combustion of marsh-gas, or phosphuretted hydrogen, or both. However, the growing doubts of physicists finally found expression in an appeal from Poggendorff, the famous editor of the *Annalen der Physik und Chemie*, for new observations that might throw further light on the question. In response to this appeal many circumstantial reports of the occurrence of the phenomenon were received. They were published in Poggendorff's *Annalen* from the year 1838 onward, and constitute a most important body of evidence on the subject.

Of these reports the one most often quoted is that from the famous astronomer Friedrich Wilhelm Bessel. He stated that thirty-one years before the time of writing, when he was twenty-three years of age, he had seen will-o'-the-wisp over a moor near Bremen. At the time of the observation he was in a boat on the Wörpe River, and saw the lights over the partly flooded low-lying land adjacent; he was therefore unable to approach them. They occurred in the form of numerous little bluish flames, which appeared and disappeared; some were stationary, while others moved in groups laterally, so that a companion of Bessel's compared them to a flock of birds. The boatmen declared that they had often seen them before in the same locality.

The example of Poggendorff was followed, in more recent times, by H. Steinvorth, of Hanover. Through the medium of both scientific and popular journals he invited not only scientific men, but the public generally, to send him reports and descriptions of will-o'-the-wisp. In a series of articles published between 1893 and 1901[1] he collected and discussed the numerous replies received from all parts of Germany, and also reprinted a great many contributions to the subject that had been published by others, including those collected by Poggendorff; so that his memoirs are a mine of information. Steinvorth's attitude is, on the whole, skeptical; but he remains open to conviction. He appears to have had a *parti pris* in favor of the firefly explanation; though it is hard to believe that educated men, familiar with fireflies all their lives, should have mistaken these insects, the appearance of which is so characteristic, for *ignis fatuus*.

Another diligent student of will-o'-the-wisp was Hermann Fornaschon, of Lübeck. His writings, the most important of which appeared in 1899,[2] contain a great number of interesting descriptions of various luminous phenomena, some of which he accepts as genuine cases of will-o'-the-wisp, while others he excludes from that category.

Mention should also be made of W. Müller, of Erzbach, who published useful digests of the will-o'-the-wisp question; the latest in the *Meteorologische Zeitschrift* of November, 1900.

### What is Meant by "Will-o'-the Wisp"?

A great number of phenomena, differing widely from one another, have been described as "will-o'-the-wisp." Hence it is difficult to define this term; though this is a necessary preliminary to any attempt to explain the phenomenon.

When we say that various luminous appearances seen by night have been mistaken for will-o'-the-wisp we assume that there is a *real* will-o'-the-wisp—a fact not yet proved to the satisfaction of all students of the question. Some of these appearances are: (1) The phosphorescence of decaying wood ("fox-fire") and other vegetable matter. This is due to luminous fungi. According to Molisch there are some forty-five species of fungus, including about twenty species of bacteria, that have the power of luminosity.[3] He has found that moist decaying leaves are often luminous, so that the floor of a forest is sometimes illuminated on all sides with a soft white light from this source. (2) Fireflies, including glowworms (the wingless females of the firefly and the larvæ). (3) Luminous birds. Their luminosity is supposed to be due to parasitic fungi.[4] (4) Ball lightning—a phenomenon that is still as much of a riddle as "real" will-o'-the-wisp, and in some of its manifestations appears to closely resemble the latter. (5) St. Elmo's fire—the brush discharges of electricity so often seen at the tips of masts and spars on shipboard, and at the extremities of various objects, including the human body, in mountainous regions. (6) Moving lanterns, the distant lights of houses, and the other human agencies. (7) Burning gas ascending from marshes, stagnant pools, and the like. Marsh gas and other inflammable gases commonly arise from such places, and are often ignited by human agencies. This phenomenon is witnessed even in the daytime. There is also abundant evidence to prove that these gases sometimes ignite spontaneously. (8) Burning naphtha springs.

By far the greater number of the reported cases of will-o'-the-wisp undoubtedly belong to one or another of the foregoing classes. According to the believers in a "real" will-o'-the-wisp, however, there remains still another class of phenomena, which, though by no means uniform in its details, may be briefly described as follows:

Small luminous bodies, "about as large as your fist," or "the size of a candle flame," are seen hovering a few feet above the ground; not only over marshes and pools, but also over dry land. Sometimes they are stationary; at other times they appear to drift with the wind, or even to move independently of the wind. They appear and disappear, after the manner of fireflies. They do not set fire to objects with which they come in contact, and are assumed to be without sensible heat. Their color is most often described as bluish, but may be yellow, purple, green, etc.; rarely pure white. They are without odor and without smoke. Traditionally they are associated with graveyards, but very few of the immense number of cases recorded by the German writers above mentioned were actually seen in such places. The popular idea that they flee from the traveler who tries to draw near to them and follow him when he seeks to avoid them is also unsupported by the evidence thus far adduced.

### A Typical Case of Will-o'-the-Wisp.

From the vast amount of material available the following may be selected as a typical description of "real" will-o'-the-wisp. By way of preliminary it should be stated that, while the majority of recorded observations of will-o'-the-wisp have been made in the summer and early autumn, the opinion prevails, especially in Catholic countries, that this phenomenon is most common at the Advent season, which begins at the end of November. This belief has been explained by Carus Sterne[5] as arising from the fact that the first mass of this season is celebrated at 5 o'clock in the morning, whence the inhabitants are obliged to be abroad before daybreak, and have unusual opportunities of observing this nocturnal meteor.

Prof. Wenzel Horák relates[6] that during his boyhood

[1] Jahreshefte des naturwissenschaftlichen Vereins für das Fürstentum Lüneberg, 13, 1895, p. 1–84; 14, 1898, p. 7–61; 15 1901, p. 19–44.

[2] "Kritische Betrachtung der Irrlichterfrage," Archiv des Vereins der Freunde der Naturgeschichte in Mecklenburg, 53, 1899, p. 34–93.

[3] Smithsonian Rept., 1905, p. 351–362.

[4] See T. D. Pigott, "Luminous Owls and the 'Will-o'-the-Wisp,'" *Contemporary Review*, 94, 1908, p. 64–72.

[5] *Prometheus*, 7, 1896, p. 316–317.

[6] *Globus*, 1896, p. 11–12.

he often saw will-o'-the-wisp at the Advent season over the fields and meadows of his native village of Nemcits, in Moravia. They were, in fact, familiar to every inhabitant of the village. For eight years he served as acolyte in the parish church, and on his way to the early mass, with various companions, saw sometimes two or three, sometimes as many as twenty or thirty of these lights. They appeared on calm moonless nights, in both clear and cloudy weather. Moving with great rapidity they would sometimes rush together, at other times scatter; spring up and down; appear and disappear; and would continue their pranks until daybreak.

"I remember one night in particular," he says; "the weather was fine; the ground was slightly frozen; a little snow lay in the furrows; the air was crisp and dry. Hardly had we left the village when we saw several will-o'-the-wisps dancing over the meadows. One was especially pretty, and was jumping up and down in a lively manner. I pointed to it, with the remark. 'That's a beautiful will-o'-the-wisp.' My companion struck down my finger, saying, 'You must not point at a will-o'-the-wisp; if you do he will molest you.' At that moment the will-o'-the-wisp rushed toward us; halted at a distance of twenty paces, jumping up and down; then retreated and danced about with some others; again approached us; and so on."

Horák says that these lights were often discussed among the villagers, the men generally attributing them to natural causes, while many of the women believed them to be the souls of unbaptized infants; a common superstition in many parts of Europe.

Years afterward—viz., in 1895—Horák revisited his old home, and inquired of an uncle whether the lights were still seen. The latter appeared surprised at the question. "Of course," he replied. "Why should they not be?"

The foregoing narrative will call to the reader's mind the characteristic appearance of fireflies, but there are two objections to this simple explanation: (1) Fireflies are not abroad in December, and (2) dwellers in the country are so familiar with the appearance of these insects that they could hardly mistake them, habitually, for something else.

### The Chemistry of Will-o'-the-Wisp.

Granting the reality of will-o'-the-wisp, there are, up to the present time, two plausible, though hardly convincing theories as to its origin.

1. The phenomenon may be a particular manifestation of ball-lightning. This hypothesis, however, only begs the question, for the origin of ball-lightning is still a mystery.

2. Some interesting experiments in the artificial production of will-o'-the-wisp have recently been made by a Belgian chemist, M. Léon Dumas.[1] This *savant* agrees with all other students of the question that marsh gas (methane, $CH_4$) cannot produce the characteristic appearance of will-o'-the-wisp; it diffuses too rapidly in the air, and, moreover, is not spontaneously combustible. On the other hand, phosphuretted hydrogen (phosphine, $PH_3$), though it takes fire spontaneously in the air, produces thick wreaths of smoke when burning, and has a powerful odor of garlic, or of putrid fish. Neither of these features has been reported in connection with will-o'-the-wisp.

Dumas accordingly decided to experiment with sulphuretted hydrogen ($H_2S$) combined with phosphine. In his garden he produced a small quantity of sulphuretted hydrogen, by decomposing ferrous sulphide with sulphuric acid in an ordinary vegetable tin. When this gas was being actively disengaged he threw in a very small fragment of calcium phosphide, the reaction of water on which produces phosphine.

The sulphuretted hydrogen alone produces bubbles of gas that appear luminous in the dark, but the odor of this gas (that of rotten eggs) is powerful and unmistakable. But when the phosphine, disengaged intermittently, sets fire to this gas, a transient bluish flame is produced, without noise or odor, and without the characteristic smoke-wreaths of burning phosphine; and the sulphur dioxide ($SO_2$) produced by the oxidation of the sulphuretted hydrogen ($H_2S$) causes the precipitation of sulphur in the form of an impalpable powder. The whole forms a little luminous cloud that floats away and, according to Dumas, presents altogether the appearance commonly assigned to will-o'-the-wisp.

Both phosphine and sulphuretted hydrogen are produced in the decay of animal substances. The brain and the spinal cord are rich in both sulphur and phosphorus. The body of an animal, buried in some wet place, would accumulate the two gases in question under pressure in the skull and spinal canal; and being of nearly the same density they would force their way out simultaneously or nearly so. Thus it appears possible that "real" will-o'-the-wisp may arise from the decomposition of the bodies of animals; a belief that has long been held, but the *rationale* of which M. Dumas seems to have first made clear.[2]

[1] *La Nature*, 38, 1er semestre, 1910, p. 30-31.

## Science Notes

**The Persistence of Typhoid Bacilli After Recovery.**—It is well known that a person may harbor typhoid bacilli in his body for a long time after recovery from the disease. An extreme instance in point is cited in *Cosmos* typhoid germs having been found in a cyst operated upon thirty-eight years after recovery of the patient from typhoid.

**Carbon From Coal Tar.**—It is reported in the *Revue électrique* that a Stockholm firm is successfully working a process for separating carbon from coal tar; the black color of this is due to the presence of fine particles of suspended graphitic carbon. The material thus recovered should be well adapted for lamp carbons, crucibles and the purposes for which graphitic carbon is commonly used.

**Domesticated Elephants in Siam.**—The number of tame elephants in Siam is estimated at 3,000. These animals give most valuable services, and it is greatly to be regretted that they are diminishing in numbers. As a consequence of this their price is increasing. At the present time a male fetches about $2,500 and a female $1,800. The elephant is mature at twenty-five, reaches its full vigor at thirty-five, and lives to an age of eighty-five to a hundred and ten years.—*Cosmos.*

**Mammoth Fat.**—The Russian chemist Chestakow has made an examination of the fat contents of the mammoth cadavers, found in the Siberian ice. It proved to be surprisingly low, compared with the amount of acids present. At the low temperature and in the absence of micro-organisms, the conversion of the original fat into fatty acids had been accomplished by the sole agency of light and air. The fat of these extinct animals differs from that of the present day animals principally in its lack of stearic acid.

**The Use of Calcium Carbide in Surgery.**—Among the varied uses which calcium carbide has found must now be numbered that of surgical cautery and dressing for wet sores. Dr. Desguins, as reported in *Cosmos*, recommends calcium carbide on the following grounds: 1. It does not attack the sound, dry skin; its effect remaining localized and being, moreover, naturally graded in proportion with the degree of moisture of the affected portions. 2. It does not cause much pain, and has a hemostatic and antiseptic action, while being free from toxic effects. Good results are said to have been obtained in the treatment of malignant tumors.

**The Use of Saccharine.**—In the majority of countries the use of saccharine is prohibited, except as a therapeutic agent. There are, however, a few exceptions, such as Egypt. In such cases we have means of observing what would happen if the use of the substance were generally permissible. In Egypt saccharine is employed especially in the manufacture of aerated waters. The consumption of lemonade and similar drinks at Cairo is enormous, reaching a million bottles a year. In order to obtain the requisite sweetness, 20 centigrammes of saccharine per liter must be employed. Hence, Cairo alone consumes over 300 kilogrammes (661 pounds) of saccharine, which takes the place of 165,000 kilograms (363,000 pounds) of sugar, that is to say, 550 times the weight of saccharine. The chemist of the Khedive found that out of twenty lemonades, submitted from different sources, only one was sweetened with sugar. The publication *Cosmos*, from which this note is taken, does not mention that any ill effects have been observed as resulting from this very extended use of saccharine.

**Why the Hungry Man Tightens the Belt.**—With the steady increase in the price of food-stuffs, the following scientific investigation on the suppression of hunger, taken from *Vossische Zeitung*, may doubtless be of general interest. Remembering the habit of tramps to tighten their belts when hungry, Prof. Dr. Rudolf Lennhoff decided to investigate the efficiency of this simple remedy in actually suppressing hunger. Assisted by physicians he made use of the property of the X-rays of being arrested by metals and their salts. Persons were given drinks which contained in suspension salts of bismuth or levigated lodestone, or they were required to eat solid food, such as mashed potatoes, which had previously been mixed with metallic salts. The following results were obtained: In the case of solid food, a contraction of the stomach could be observed, and a relatively small quantity proved to be sufficient to satisfy the appetite. When liquid food was given in the ordinary way, i. e., by swallowing, the contraction was considerably less, and a larger quantity was necessary for satiation. In a third experiment the liquid was introduced into the stomach through a tube; in this case twice the quantity of liquid was required. These experiments showed that the mechanical stimulus of swallowing by reflex action causes a contraction of the stomach, thus accelerating satiation. This suggested that by artificially increasing the pressure on the stomach satiation could be accomplished with a smaller quantity of food. The trick of the hungry tramp was therefore resorted to, and a belt was applied tightly around the waist of the eater. The result was as anticipated. To make sure and exclude any influence of suggestion, the same experiments were made on insane persons who were allowed to eat as much as they pleased. The result was in all cases the same, they all ate less when the belt was strapped tight around their waist. Other experiments were then made on persons who were given the prepared liquid food through a tube introduced into the throat. In all these cases the belt had no effect whatsoever. The sense of satiation is therefore influenced by the act of swallowing, which causes a contraction of the stomach.

[2] A similar explanation, though in less precise terms, was offered by T. L. Phipson, in *Belgravia*, v. 6, 1868, p. 392-398. The experiment of Dumas, described above, has been repeated at the Bureau of Standards, in Washington, at the request of the writer of the present article, but with only partial success. Explosive flames are readily produced in the containing vessel, but the puffs of white smoke given off are hardly, if at all, luminous. Perhaps the laboratory conditions do not reproduce with sufficient fidelity those of Nature; however, we believe will-o'-the-wisp is still "elusive."

ERRATUM:—We wish to correct an unfortunate error in the caption of the illustration (Fig. 1) of Prof. Carpenter's paper on the Shumann Haines low-pressure engine. In the caption this is referred to as a "turbine." The engine is, of course, of the reciprocating type.

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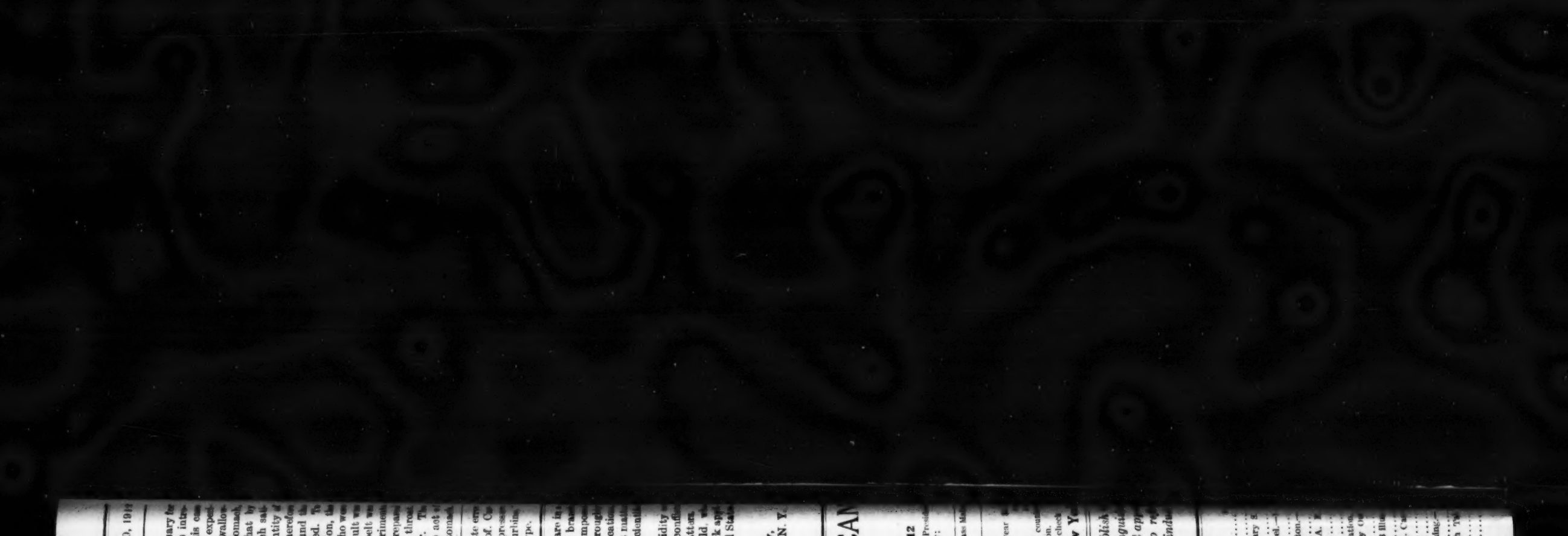
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